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Applied Mechanics Reviews

A Critical Review of the World Literature in Applied Mechanics

L. H. DONNELL, *Editor*

T. VON KÁRMÁN, S. TIMOSHENKO, *Editorial Advisers*

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Abbreviations of units follow the standard of Abbreviations for Scientific and Engineering Terms of the Am. Standards Assoc. Examples: psi (pounds per square inch); cps (cycles per second); mph (miles per hour).

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A Critical Review of the World Literature in Applied Mechanics

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Communications and Queries

Concerning Rev. 731, June 1949, "Plastic deformation," by Kachanov, Ilyushin, Mostow, Gleyzal, et al.

Editor:

When one considers that Dr. Gleyzal and I wrote about the identical series of tests, made the same assumptions regarding the plasticity conditions, and differ in our methods of solution solely in that Gleyzal solves a differential equation of equilibrium whereas I solve an equivalent variational problem, Dr. Nádái's review appears rather incomprehensible. Apparently the validity of an assumption depends upon who makes it.

Not mentioned in Nádái's review is the fact that my results are in very good agreement with Gleyzal's and with the experimental data. Unfortunately this is not evident except through careful reading of both papers. The equality of the ratios of the principal stress and strain differences, of which Nádái makes a big issue is not used anywhere in my solution.

One final point might be mentioned. My paper was included in this book without either my previous knowledge or consent.

Wolfe Mostow

Correction of Rev. 858, July 1949, George Winter and R. H. J. Pian, "Crushing strength of thin steel webs."

Two editorial errors were made in this review:

The maximum thickness of the steel sheet used was 0.1478 in. (not 0.473 in.). The loads were found to be largely independent of depth of the web (not of the flange).

Translations of technical articles

Directory of Translators, Southwestern Research Institute, San Antonio, Texas, managed by Wayne Kalenich, librarian, furnishes (without charge) information about language specialists competent in various subject fields of science and technology. Translators and interpreters are urged to register with the Directory.

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Theoretical and Experimental Methods

(See also **Revs. 1095, 1100, 1106, 1115, 1136, 1142, 1156, 1173**)

1085. R. H. Parsons, "History of the institution of mechanical engineers," Institution of Mechanical Engineers, London, 1947. Cloth, 9.1 × 6.2 in., 299 pp., 56 figs., $3.60.

This book was published to commemorate the one-hundredth anniversary of the founding of The Institution of Mechanical Engineers (1847–1947). The work consists of three main parts: a history of the Institution, selected topics discussed at meetings during the first fifty years, and remarks about early members of note. H. M. Trent, USA

1086. G. E. Williams, "Technical literature," Allen and Unwin, Ltd., London, 1948. Cloth, 5.25 × 7.5 in., 117 pp., 1 fig., $2.00.

This compact readable book outlines the technique of writing articles or "papers." It presents not only explicit and motivated instructions, from initial putting of thoughts in order, through the rough and finished manuscript, to completed page proof, but it contains in addition an appendix on psychological principles. This appendix explains how to obtain and retain the reader's interest, and the earnest seeker of knowledge on how to write technical material might be well advised to study it first. Although the author in advance disarms criticism of necessarily dogmatic assertions in his book (and there are many debatable points of detail), he has succeeded in exemplifying his own advice on good, interest-sustaining technical writing. Only in sections VI and VII, describing editorial procedures and technicalities of printing, will the general reader's interest lag. The other chapters on method of presentation, choice of words, organization and preparation of manuscripts should prove most helpful in guiding technical writers to better style and improved written presentation of scientific and engineering material. K. W. Miller, USA

1087. L. Y. Neishooler, "On optimal double-entry tabulation of a function" (in Russian), *Bull. Acad. Sci. USSR Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. tekh. Nauk)*, Aug. 1948, no. 8, pp. 1169–1191.

This paper considers in still greater detail [*C. R. Acad. Sci. URSS*, 1942, vol. 36, pp. 121–124; *Bull. Acad. Sci. USSR. Ser. tech. Sci. (Izv. Akad. Nauk SSSR Ser. Tekh. Nauk)*, 1947, pp. 597–608; *Trav. Inst. Math. Stekloff*, 1947, vol. 20, pp. 87–108] the tabulation of a function of three variables by means of double-entry tables. Nine possible cases of tabulation are discussed and compared.

Courtesy of Mathematical Reviews D. H. Lehmer, USA

1088. L. J. Comrie, "Chambers's six-figure mathematical tables, vols. 1 and 2," D. Van Nostrand, New York, 1949. Cloth, 10.25 × 6.9 in., 576 pp., no figs., $10 per vol., $17.50 per set.

This work appears 105 years after the first publication of *Chambers's Mathematical Tables*, and its plan is based on the recommendations of L. J. Comrie, a leading authority in the field. The basic tables, with two exceptions, have been limited to 6 figures, which—in Comrie's opinion—cover 95 per cent of computational requirements. The two exceptions are the additional 8-figure logarithms of numbers from 1 to 1000, and from 1.00000 to 1.10000. The natural trigonometric functions and their logarithms are given for angles expressed either in degrees, minutes and seconds, or degrees and decimals, or radians. Special tables for small or large angles are included. Exponential and hyperbolic functions and their logarithms are given.

There are some 18 additional tables, such as of the Gamma function and its logarithm, of the probability integral, powers, roots, factorials, primes, numerical differentiation and integration, etc.

Special attention has been given to the choice of type face for the figures ("old style," with heads and tails). Rules are used sparingly. A 26-page introduction explains the use of the tables, and touches on some essential questions, such as the number of places to be retained for a given number of figures in the angle, etc. Ed.

1089. N. W. McLachlan, "Modern operational calculus with applications in technical mathematics," Macmillan and Co., Ltd., London, 1948. Cloth, 5.5 × 8.2 in., 218 pp., 26 figs., $5.00.

This is a book on the theory and applications of the Laplace transformation directed especially to graduate engineers and technologists. The six chapters making up the body of the book carry the following headings: The Laplace transform; Theorems or rules of the operational calculus; Solution of ordinary linear differential equations with constant coefficients; Evaluation of integrals and establishment of mathematical relationships; Derivation of Laplace transforms of various functions; Laplace transforms for a finite interval; Impulses. The appendices include brief discussions of Heaviside's unit function, the convergence of infinite series and integrals, and the inversion integral.

Throughout the book, the properties of the transformation are copiously illustrated. Many of the illustrative examples deal with Bessel functions. The physical applications treated include problems in mechanical systems, electrical circuits, transmission lines, compressional shock waves in fluids and propagation of sound in viscous media. The 250 exercises given toward the end of the book include problems on convergence, the derivation of special properties of transformations, the derivation of transforms and other properties of special functions, of Bessel functions in particular, as well as the solution of problems in ordinary and partial differential equations and integral equations. The book ends with a list of about 80 transforms and a short bibliography. Most of the inverse transformations made in the present book are performed with the aid of short tables of transforms.

R. V. Churchill, USA

1090. Harry D. Huskey and Douglas R. Hartree, "On the precision of a certain procedure of numerical integration," *J. Res. nat. Bur. Stands.*, Jan. 1949, vol. 42, pp. 57–62.

In the first part of this paper H. D. Huskey tests the validity of the expression derived by H. Rademacher ["On the accumulation of errors in processes of integration on high-speed calculating machines," *Proceedings of a Symposium on Large-Scale Digital Calculating Machinery*, Harvard University Press, Cambridge, Mass., 1948] for the standard deviation of an accumulated round-off error, by carrying out the numerical integration of a simple system of ordinary differential equations for a number of intervals of the independent variable. The results are compared with the exact solution, after allowance is made for truncation errors. In certain portions of the integration it is found that the round-off error accumulates in an apparently systematic fashion.

The second part of this paper consists of an appendix by D. R. Hartree in which the causes for lack of randomness of round-off errors in integration problems are examined. A criterion is set up to detect the cases in which this phenomenon may occur to a marked degree. In such cases the situation may be remedied by a change in the interval of integration. H. Polachek, USA

1091. Paolo Gazzana Priaroggia, "The approximate numerical solution of electrostatic fields and analogous harmonic fields" (in Italian), *Energia elett.*, Oct. 1948, vol. 14, pp. 533–555.

After pointing out the advantages of the numerical methods for the approximate solution of problems arising from harmonic fields, procedures that lead to finite expressions of solutions of Laplace's equation for plane electrostatic fields with a uniform dielectric are illustrated. The fundamental principles that are common to the various numerical methods are presented, with especial emphasis on the iteration method. The method of transformation of Laplace's equation is then extended to the case of fields with rotational symmetry and to mediums with a finite number of discontinuities.

A series of standard routines that will allow a nonspecialized operator to carry on the computations are presented, and their use illustrated with an example. Ernesto Saleme, USA

1092. R. Grammel, "A simple representation of tensors and affinors (dyadics)," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 394–403.

For two-dimensional tensors the author makes use of the fact that for each direction ϕ the tensor defines two components N_n and N_t, along and across this direction. The two polar graphs $(1 + N_n/a, \phi)$ and $(1 + N_t/a, \phi)$ are offered as the title representations (the constant a is chosen large enough to make all radii positive and the plot possible). A similar procedure is suggested for the space. A. W. Wundheiler, USA

1093. M. P. Geppert, "Confidence limits and fiducial distribution" (in German), *Z. angew. Math. Mech.*, Nov.-Dec. 1947, vol. 25/27, pp. 253–263.

The paper deals with the logical foundations of statistical inference. An introduction to the Neyman-Pearson theory is given, particularly in the case when one wants to test (or estimate) a parameter θ from a sample of a one-dimensional statistical distribution. The author uses the a priori probability function $\omega(\theta)$ for θ in order to compare the classical theory (Bayes), based on inverse probabilities, with modern theories (Neyman-Pearson, Fisher). Finally, he discusses R. A. Fisher's fiducial probability, and its use in setting confidence limits for θ. The probability aspects of the different methods are pointed out clearly.

Nils Blomqvist, Sweden

Mechanics (Dynamics, Statics, Kinematics)

(See also Revs. 1106, 1115, 1186)

1094. F. M. Deementberg, "The finite displacement of a spatial four-linkage with cylindrical pairs and the case of passive constraints" (in Russian), *Appl. Math. Mech.* (*Prikl. Mat. Mekh.*), Nov.-Dec. 1947, vol. 11, pp. 593–602.

A four-bar spatial linkage in which the links are free to slide along three of the hinges is movable with one or more degrees of freedom. The constant parameters of this system are the lengths of the links (a length is the perpendicular distance between the hinges in a link). The variables are the angles between the links. The relation between the variables is derived in terms of the parameters by means of vectors and finally expressed in analytic form.

Under special conditions, as in the case of a Bennett linkage in which the opposite lengths are equal and the opposite twists are equal, but the hinges do not intersect, motion of the linkage is possible only when the lengths are proportional to the sines of the twists. In this case the bars of the linkage do not need to make

use of the freedom to slide along the hinges. Such a condition is called a passive constraint. Other special cases in which passive constraints exist are the spherical linkage in which all the hinges intersect in a point, the plane linkage, and various degenerate cases such as the three-bar and the double two-bar.

M. Goldberg, USA

1095. **N. N. Ghosh, "Rigid rotation in hyperspace,"** *Bull. Calcutta math. Soc.*, Sept. 1948, vol. 40, pp. 116–122.

The object of this paper is to study by a matrix method the finite rotation of a rigid body about a point in Euclidean n-space. Starting with the simplest rotation occurring in a plane where a skew-symmetric matrix of rank 2 is involved, it is seen that a $2r$-dimensional rotation is associated with a skew-symmetric matrix of rank $2r$. The matrix method here adopted depends on some new types of matrices introduced by Ghosh [*Bull. Calcutta math. Soc.*, 1940, vol. 32, p. 110]. In this paper the author obtains representations of (1) plane rotation in n-space, (2) $2r$-dimensional rotation, and (3) the composition of plane rotations when the resultant rotation is also plane.

L. M. Milne-Thompson, England

1096. **Victor Vâlcovici, "On the equations of motion of a rigid body of variable mass"** (in French), *C. R. Acad. Sci. Paris*, Jan. 3, 1949, vol. 228, pp. 52–53.

The title equations are given in vectorial form for the case of particles being discharged or captured at a given relative velocity. The paper is obsolete. For a modern and detailed treatment of rocket equations by Gantmacher and Levin, see Rev. **1442,** Sept. 1948. A. W. Wundheiler, USA

1097. **V. V. Dobronravov, "Analytical dynamics in anholonomic coordinates"** (in Russian), *Learned Notes Moscow State Univ. Mech.* (*Uchenya Zapiski Moskov. Gos. Univ. Mekh.*), 1948, vol. 2, pp. 77–182.

This doctoral dissertation, written like a textbook, is purely formal in content. It presents a step-by-step recasting of the standard formulas, equations and theorems of analytical dynamics into forms valid for first-order anholonomic systems. Tensor symbolics is used throughout.

Almost everything in the paper is derived twice: in the first part for holonomic systems and anholonomic coordinates, in the second part for anholonomic systems. The formulas and the proofs are the same in both cases. The transition from the classical to the anholonomic case is a matter of differential-algebraic routine, and a 10-page version of the paper would be quite satisfactory for many readers, especially those accustomed to tensor symbolics. In this form the paper would constitute an almost necessary appendix to every text in analytical dynamics. In its present form it has more of a popular appeal.

The general routine of transition from the classical to the anholonomic case may be briefly described as follows. The symbols $d\pi^\alpha$ and $\partial/\partial\pi^\alpha$ are defined by means of the equations (an index duplicated in a monomial is a summation index)

$$d\pi^\alpha = A_i{}^\alpha\, dq^i, \qquad \partial/\partial q^i = A_i{}^\alpha\,(\partial/\partial\pi^\alpha),$$

where q^i are some generalized (true) coordinates of the system. If the first forms are not completely integrable, the symbols π^α do not denote any numbers, and are said to represent "anholonomic coordinates." Only the defined symbols $d\pi^\alpha$ and $\partial/\partial\pi^\alpha$ enter into the equations, and all first-order relations retain their old form, as if π^α were true coordinates. Not so with second-order relations. Unless $d\pi^\alpha$ are exact differentials, we have

$$\delta d\pi^\alpha - d\delta\pi^\alpha = \gamma_{\lambda\mu}{}^\alpha d\pi^\lambda d\pi^\mu, \quad \partial^2F/\partial\pi^\lambda\partial\pi^\mu - \partial^2F/\partial\pi^\mu\partial\pi^\lambda = \gamma_{\lambda\mu}{}^\alpha(\partial F/\partial\pi^\alpha),$$

and the γ's disappear whenever π^α are holonomic. The γ's enter linearly in all the second-order equation in the form of an easily predictable additive term. Thus Lagrange's equations assume the form (due to Boltzmann and Hamel)

$$\frac{d}{dt}\frac{\partial T}{\partial\dot\pi^\lambda} - \frac{\partial T}{\partial\pi^\lambda} + \gamma_{\lambda\mu}{}^\alpha\pi^\mu\frac{\partial T}{\partial\dot\pi^\alpha} = Q_\lambda,$$

and Hamilton's

$$\dot\pi^\alpha = \partial H/\partial p_\alpha, \quad \dot p_\lambda = -\partial H/\partial\pi^\lambda + \gamma_{\lambda\mu}{}^\alpha p_\alpha(\partial H/\partial p_\mu).$$

Similar modifications occur in all the other formulas.

The most important omission noticed by the reviewer is that of the condition for true anholonomicity (that is, when no transformation of variables will reduce the γ's to zeros). Some interminable computations (in the proof of Poisson's bracket theorem, for instance) can be spectacularly simplified by working with scalar forms. The notations do not make full use of the modern devices in tensor symbolics (due to Schouten and his school) resulting in superior organization of the shape of the formulas.

A. W. Wundheiler, USA

1098. **M. Maurice Parodi, "Application of a theorem by Hadamard to the study of the stability of systems"** (in French), *C. R. Acad. Sci. Paris*, Mar. 7, 1949, vol. 228, pp. 807–808.

The author bases his theory on a known theorem of Jacques Hadamard. He gives sufficient conditions for the roots of an equation of the type

$$\begin{vmatrix} \dfrac{a_{11}+b_{11}z}{\alpha_{11}+\beta_{11}z} & a_{12} & \cdots & a_{1n} \\ a_{21} & \dfrac{a_{22}+b_{22}z}{\alpha_{22}+\beta_{22}z} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & \dfrac{a_{nn}+b_{nn}z}{\alpha_{nn}+\beta_{nn}z} \end{vmatrix} = 0$$

to have negative real parts. Such a condition is useful in many stability problems. D. DeMeulemeester, Belgium

1099. **R. A. Moyer, "Braking and traction tests on ice, snow, and on bare pavements,"** *Proc. Highw. Res. Bd.*, 27 Ann. Meet., 1948, pp. 340–360.

This article describes a series of tests run with different types of automobiles and trucks, using various kinds of tires and chains or sanders, on lake and road ice. Most tests were performed on lake ice, the basis of measurement being the distance required to stop a vehicle from a speed of 20 mph, to accelerate it to 10 mph under the best motor conditions, or else to measure the maximum speed at which the car could take a curve of 150 feet radius. Comparative tests were run on dry, belted concrete pavements and on road ice. Great care was taken to eliminate the human factor in the test by using all sorts of equipment such as electrical stopping-distance guns, fifth-wheel tachometer, and, even from the driving point of view, the operators were expert test drivers or test engineers from companies co-operating on the project.

The results are given as comparative figures rather than graphs, as no attempt seems to have been made as yet to establish coefficients of frictions of ice as functions of the numerous variables involved in winter driving. Robert Quintal, Canada

Gyroscopics, Governors, Servos

(See also Rev. 1174)

1100. A. M. Letov, "On a special case of investigation of stability of regulating systems" (in Russian), *Appl. Math. Mech. (Prikl. Mat. Mekh.)*, Nov.-Dec. 1948, vol. 12, pp. 729–736.

This paper supplements a previous paper of A. I. Lourye (1945) using the transformation of the system of differential equations of motion to canonical variables. The author considers the special case in which the linear matrix of the canonical transformation has but two equal characteristic roots. Stability conditions are derived for this case. One numerical example serves as an illustration of the method. Robert Szewalski, Poland

1101. Rufus Oldenburger, "A method of obtaining constant speed from a variable speed source," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 143–151.

This paper is a very elementary analysis of an hydraulic variable-ratio drive. The more or less obvious conclusion is drawn that the governor should be as fast as possible for best results. Charles Concordia, USA

Vibrations, Balancing

(See also Rev. 1133)

1102. J. E. Brock, "Theory of the damped dynamic vibration absorber for inertial disturbances," *J. appl. Mech.*, Mar. 1949, vol. 16, pp. 86–92.

This paper considers a damped dynamic vibration absorber for a system having a driving-force amplitude proportional to the square of the driving frequency. Following an analysis similar to that given by Den Hartog for the usual damped dynamic absorber, the author determines the criteria for optimum tuning. The results are also presented in graphical form. An illustrative example is included. Albert I. Bellin, USA

1103. Henri Pailloux, "On the small vertical movements of a heavy wire" (in French), *C. R. Acad. Sci. Paris*, Mar. 7, 1949, vol. 228, pp. 808–810.

A functional equation for the most general vertical small vibrations of a heavy, inextensible, flexible wire is established. This equation contains four arbitrary functions which can be determined from the initial and boundary conditions. Hints are given for an application to the motion of a rope having one end fixed and the other fastened to a mast undergoing elastically damped vibrations. Aurel A. Beles, Rumania

1104. Théodore Vogel, "On the application of linear differential equations with periodic coefficients to problems of elastic supports" (in French), *C. R. Acad. Sci. Paris*, Jan. 10, 1949, vol. 228, pp. 162–163.

The author investigates the vibrations of a continuous, one-dimensional system (a cable, rod, etc.) on elastic discrete supports whose spacing is an appreciable fraction of the total span. Expressing the elastic reaction F as a series $\sigma \Sigma(-e^{ix})^m$, the eigenvalue problem with the equation $\Sigma_1^n a_p(d^p y/dx^p) = 0$, $a_0 = \lambda + \sigma + F$, while the other a's are constants. The author shows that a solution of the form $y = \Sigma b_m \exp i(m + \mu)x$ and applies this result to the cases of a cable under tension ($n = 2, a_1 = 0$) and of a beam ($n = 4, a_1 = a_2 = a_3 = 0$). In the first of these two cases the eigenvalue problem reduces to Hill's equation encountered by Noether in the theory of electric filters with lumped impedances [see *Proc. Third int. Congress appl. Mech.*, Stockholm, 1930]. Henry Faver, Switzerland

1105. Nicoletta Cotugno and Clelia Mengotti-Marzolla, "Approximation of the lowest frequency of a homogeneous, elliptic, built-in plate" (in Italian), *R. C. Accad. Lincei*, Dec. 1948, ser. 8, vol. 5, sem. 2, pp. 324–326.

The lowest frequency of an elliptic plate, built-in along its boundary, is determined by means of a polynomial function and the energy method, for ratios of the semiaxes varying from 1 to 0.1 by steps of 0.1. Mario G. Salvadori, USA

1106. R. D. Davies and A. F. Cook, "The motion of a railway axle," *Proc. Instn. mech. Engrs.*, 1948, vol. 158, no. 4, pp. 426–436.

The authors have investigated, by means of analysis and model experiments, the effect of the impacts between flanges and rail on the motion of a single free axle and pair of wheels. In the test apparatus the rails were circular rings mounted on a rotating drum. The wheel and axle unit rested on the moving track and were so suspended as to have every degree of freedom except that of fore-and-aft translation. The variables in the experiment were dynamical properties of the axle unit, ratio of total to unsprung load, wheel and rail profiles, coefficient of friction, flange clearance, lateral stiffness of track, and the speed.

The principal conclusions from the tests were: (1) the speed at which oscillation occurs varies inversely as the square root of the unsprung mass; (2) lateral stiffness of track has little effect; (3) with new wheels, the violence of oscillation increases with flange clearance. Arguments are given to justify the use of a single-axle unit in the tests rather than a double-axle truck combination. Dana Young, USA

Wave Motion, Impact

(See also Revs. 1158, 1175, 1195, 1204)

1107. Léopold Escande, "A study of water-hammer due to simultaneous action of the distributor and water gate" (in French), *C. R. Acad. Sci. Paris*, Mar. 21, 1949, vol. 228, pp. 978–980.

In a previous paper the author presented a method of calculating the water hammer due to simultaneous operation of the turbine distributor and of a gate at the mouth of a water-power conduit. The application of this calculation to the Genissiat plant shows that no overload is produced by the gate. Giulio de Marchi, Italy

Elasticity Theory

(See also Revs. 1092, 1129, 1139, 1198)

1108. Giuseppe Grioli, "The structure of the Airy function for multiply-connected domains" (in Italian), *G. Mat. Battaglini*, 1947, vol. 77, pp. 119–144.

In plane strain and generalized plane stress in the absence of body forces, the problem of equilibrium for a homogeneous isotropic elastic body involves the determination of a biharmonic Airy function $F(x,y)$. The paper deals with the case where the body is multiply connected, F and its first derivatives being then multiple valued. The case of a doubly connected body (one hole) is treated in detail. Taking the origin in the hole, the author shows that F must have the form $F = \phi - \theta(M + yX - xY)/2\pi$, where ϕ is biharmonic, single valued and with single-valued first

derivatives, $\tan\theta = y/x$, and X, Y, M represent the resultant force and couple across any circuit drawn in the body and enclosing the hole. The next step is to express ϕ, in the manner of Poincaré, in the form

$$\phi = \phi_0 + \phi_1 + (\alpha\rho^2 + \beta x + \gamma y + \delta)\log\rho + a\cos 2\theta + b\sin 2\theta,$$

where ρ,θ are polar coordinates, the coefficients are constants, and ϕ_0,ϕ_1 are biharmonic, the former regular in the portion of the plane inside the outer boundary of the body, and the latter regular in the portion of the plane exterior to the hole and converging at infinity. The general problem is then analyzed in two parts: (*a*) when there are no stresses across the boundary and the displacement is multiple valued, and (*b*) when there are stresses across the boundary and the displacements are single valued. The meaning of the constants occurring in F is examined. Series developments for ϕ_0 and ϕ_1 are suggested. The method is extended to cover multiple connectivity of any order. J. L. Synge, Ireland

1109. **E. Sternberg and M. A. Sadowsky, "Three-dimensional solution for the stress concentration around a circular hole in a plate of arbitrary thickness,"** *J. appl. Mech.*, Mar. 1949, vol. 16, pp. 27–38.

The solution for the stress in a sheet containing a circular hole and subjected to uniform traction or pressure in both directions far from the hole, has been well known for a long time as the "solution of G. Kirsch." This solution is for the two-dimensional cases of plane stress and plane strain. Until now there has been no solution for the case of a plate whose thickness cannot be neglected compared with the diameter of the hole.

This lack is filled in the present paper. In this case there are stresses in the direction normal to the plane of the plate, so that the stress becomes three-dimensional. For the limiting case of infinitesimally thin plates the solution coincides with that of Kirsch.

There are two fundamental solutions, for the case of equal tractions and for the case of pure shear. For the first case the three-dimensional exact solution is the same as the two-dimensional solution, but the last case necessitates a new solution, which the authors obtain as an approximate solution with the help of the principle of the minimum of the total strain energy. This approximate solution is evaluated and presented in graphs. It is hoped that it will throw new light on the theory of brittle failure of plates containing discontinuities.

Ludwig Föppl, Germany

1110. **C. Bassel Smith, "Effect of hyperbolic notches on the stress distribution in a wood plate,"** *Quart. appl. Math.*, Jan. 1949, vol. 6, pp. 452–456.

The author considers an orthotropic plate with hyperbolic notches, that is one which is bounded on two sides by the hyperbola $y^2/a^2 - x^2/b^2 = 1$ and extends indefinitely in the direction of the x-axis. The resultant force on any plane perpendicular to the x-axis is statically equivalent to a force directed along the x-axis. The solution is obtained from an Airy function. Computed stresses on the y-axis are given for three values of a/b. The solution reduces to that obtained by Neuber for the case when the plate is isotropic. Stanley U. Benscoter, USA

1111. **D. I. Sherman, "On a torsion problem"** (in Russian), *Notes Acad. Sci. USSR (Doklady Akad. Nauk SSSR)*, Dec. 11, 1948, vol. 63, pp. 499–502.

An approximate solution of the torsion problem for a hollow cylinder whose exterior boundary is a circle L_1, and the interior an ellipse L_2, with coincident centers, is given. The usual complex torsion function $\varphi_1(z)$ is shown to be related to a function $\varphi(z)$, analytic in the region exterior to L_2, and vanishing at infinity. This latter function is determined by the method used by the author in investigating the state of stress in shrink-fitted members [see Rev. **300**, Mar. 1949]. Numerical calculations, performed for the case when the semiaxes a and b of the ellipse are such that $a = 3b$, and the radius of the circle $R = 4b$, indicate the effectiveness of the approximate solution.

I. S. Sokolnikoff, USA

1112. **Tadasi Isibasi, "Form factors of solids of revolution in relation to those of plane plates"** (in English), *Kyushu Univ. Res. Inst. Elast. Engng. Rep.*, no. 1, June 1947, vol. 4, 16 pp.

A simple relation is developed between the stress-concentration factor for a solid of revolution having an annular notch or fillet, and the stress-concentration factor for a plate having the same boundaries as the meridian section of the solid of revolution. Both members have an axial-tension loading.

The method used to develop the correlation between stress-concentration factors is to express the difference in the stresses in the solid of revolution and the plate in terms of the stress functions for each. Satisfaction of the boundary conditions results in an expression for the two stress-concentration factors containing two constants which are evaluated by Neuber's solutions for the solid of revolution and the plate.

Curves are presented indicating the relation between the stress-concentration factors for various fillets and notches.

M. V. Barton, USA

1113. **C. Gurney, "The effective stress concentration at the end of a crack having regard to the atomic constitution of materials,"** *Rep. Memo. aero. Res. Counc. Lond.*, no. 2285, Dec. 1945 (issued in 1949), 5 pp.

The author expresses the Inglis formulas for the stresses around an elliptical hole in terms of $k = \Delta/r$, r being the radius of curvature at the end of the long axis and Δ a small length over which the stresses are averaged. He studies in particular the case $k = 1$, pointing out that the sharpest cracks which can be expected to be obtained in practice are those having a radius of curvature at the ends of the order of atomic dimensions. When the stresses at infinity are radially symmetric, the peak stress given by Inglis is proportional to $2(a/b)$ (a and b being the semiaxes of the ellipse). The author finds that for $k = 1$ the averaged stress is about half of that value, and for $k = \infty$ ($r = 0$, $b = \infty$) the averaged stress is only $1.8(a/\Delta)^{1/2}$ instead of being infinite. A. J. Durelli, USA

Experimental Stress Analysis

(See also Revs. 1139, 1140)

1114. **Jacques Pomey, Louis Abel and François Goutel, "Development, effects and measurements of residual stresses on the surfaces of machine parts"** (in French), *C. R. Acad. Sci. Paris*, Jan. 17, 1949, vol. 228, pp. 223–225.

In this short communication it is proposed to measure the residual stresses occurring in surface layers by means of a ball-indentation test. The resistance of the material against indentation shows an abrupt drop when plastic deformations are initiated. Thus the corresponding "hardness" value is directly affected by the magnitude of the internal stresses present in the surface layer of the material, in a way which can be calculated by means of the Hertz theory. In practice, however, the relation between the

residual stresses and the hardness is to be found by experiment on preloaded samples of the same material.

J. A. Haringx, Holland

1115. C. F. Bruce, "Frictional forces in dial gauges," *Engineering*, Feb. 25, 1949, vol. 167, pp. 169–171.

Frictional forces were measured for a variety of dial gages reading in 0.001 in. to 0.0001 in. per division. The gages with highest sensitivity exhibited frictional forces which were a nonlinear function of the deflection. Since gages essentially operate in response to deflection, it is concluded that friction would not affect the gage reading except when the gage is unloading. In this case, gentle tapping of the gages improves the behavior.

George Gerard, USA

Rods, Beams, Shafts, Springs, Cables, etc.

(See also Revs. 1130, 1134, 1135, 1137, 1138, 1147)

1116. M. T. Huber, "Pure bending of curved thin-walled tubes of elliptic cross section" (in Polish), *Arch. Mech. Stos.*, 1949, vol. 1, pp. 1–22.

The author applies to the title problem a method similar to that of von Kármán for a circular cross section (1911), and of Timoshenko for a rectangular cross section (1923). The assumptions are the same as in the author's 1930 paper on bending of straight beams with flexible cross sections: there is no appreciable change in the lengths of arc elements of the mean outline of a cross section. Besides, this outline, originally an ellipse

$$(y/a)^2 + (z/b)^2 = 1,$$

changes into another ellipse

$$(y/a')^2 + (z/b')^2 = 1, \text{ where } a' = a + \beta b,\ b' = b - \beta a,$$

β being a small number.

The following formula is obtained for the increment $\Delta\alpha$ of the angle α between two cross sections, resulting from a pure bending moment M:

$$\frac{\Delta\alpha}{\alpha} = M \frac{\lambda - \nu^2}{4E(1-\epsilon^2)} \frac{R}{a^3 g} \frac{\lambda^2 J + 12 f_2}{\psi_0(\lambda J + 12 f_2) - 3\psi_1^2}.$$

The notations are: E Young's modulus, ν Poisson's ratio, R the original radius of the central line of the tube, a the major semiaxis of the mean ellipse of the cross sections, g the thickness of the tube walls, ϵ the numerical eccentricity of the mean cross-sectional ellipse, $\lambda = Rg/a^2$, J, f_2, ψ_0, ψ_1 certain functions of ϵ expressed in terms of elliptic integrals which can be tabulated.

The comparison of the special case $a = b$ with the von Kármán result reveals small numerical differences. These differences are owing to Kármán's assumption of $r = a + c\cos 2\phi$ as the polar equation of the deformed (originally circular) mean outline of a cross section. This is not the present author's assumption, and only experimental measurements, admittedly difficult, could discriminate between the two theories. W. Olszak, Poland

1117. J. A. Haringx, "On highly compressible helical springs and rubber rods, and their application for vibration-free mountings," *Philips Res. Rep.*, Dec. 1948, vol. 3, pp. 401–449; Feb. 1949, vol. 4, pp. 49–80.

In the first part of this article the author considers the problem of buckling of helical springs under simple compression or under compression combined with a twist about the spring axis. In this analysis, the spring is assumed to be made up of a series of "unclosed" circular rings connected by rigid elements. Because of shear deformations, the planes of these imaginary rings after deflection are not perpendicular to the center line of the deflected spring, and in calculating the shear deformation, the transverse force acting in the plane of the ring (and not the shear force perpendicular to the center line) must be taken as a basis. The results therefore differ from those obtained previously by Biezeno and Koch (who take this shear force to be perpendicular to the center line), particularly for the smaller ratios l_0/D_0 between active free height and mean coil diameter. The author's results show that for hinged ends, below l_0/D_0 equal to 2.62, no buckling of the spring can be expected even for deflections equal to the active free heights; this is in accordance with experimental results. A complicated analysis in which the spring is regarded as a curved bar in space shows that, when the pitch is less than half the mean coil diameter, results sufficiently accurate for practical purposes are obtained using the simple theory. Further study indicates that a small index or a small number of coils will not affect the results from a practical viewpoint, but the effects of clamping the ends are very important. The case of a rectangular bar spring is also considered.

In the second part, the author deals with helical springs under combined axial and lateral loading. The analysis differs from the usual analysis in that the shear deformation is again calculated using shear forces in the planes of the imaginary rings. The calculated results agree with measured values obtained by Gross and Lehr (where the end conditions were quite definite) and with the author's own experimental data. The effects of the end coils on the lateral rigidity are discussed while formulas are derived for calculating natural frequencies of lateral vibration for various amounts of axial compression. A. M. Wahl, USA

1118. G. Forrest, "Residual stresses in beams after bending," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 153–162.

The residual stresses in beams bent into the plastic range have been calculated on the assumption that the spring back after unloading is completely elastic. Results are given for beams with T-sections of various proportions. J. A. Haringx, Holland

Plates, Disks, Shells, Membranes

(See also Revs. 1105, 1116, 1121, 1122, 1132, 1138)

1119. H. J. Greenberg and W. Prager, "Direct determination of bending and twisting moments in thin elastic plates," *Amer. J. Math.*, Oct. 1948, vol. 70, pp. 749–763.

The authors extend the method of Prager and Synge [*Quart. appl. Math.*, 1947, vol. 5, pp. 241–269] to the computation of the moments themselves in transversely loaded thin elastic plates with fixed or simply supported edges. A state of stress or of moments in the entire plate is regarded as a point in function space, and strain energy is used as a metric. A geometric language is employed to develop ideas and formulas for an approximate solution (center of a hypercircle) and maximum over-all, although not local, error (radius of the hypercircle).

Three states are used: (1) the completely associated state which satisfies equilibrium and the boundary condition of zero moment along the simply supported portion of the edge; (2) an orthonormal series of homogeneous associated states which satisfy the boundary condition of (1) but are in equilibrium with zero transverse load; (3) an orthonormal series of complementary states which satisfy compatibility and the boundary condition on deflection. The greater the number of states taken, the closer the

total strain energy for the approximate solution approaches the strain energy for the actual case. Despite a low limit on over-all error, individual moments may occasionally be in considerable error.

Application of the method is made to the uniformly loaded clamped square plate. Agreement within 5 per cent with Nádái's values [*Elastic plates* (in German), 1925, p. 184] at two points is found, when the radius of the hypercircle is less than 0.001.

D. C. Drucker, USA

Buckling Problems

(See also Rev. 1117)

1120. **M. A. Lavrentiev and A. U. Ishlinsky, "Dynamic forms of loss of stability of elastic systems"** (in Russian), *Notes Acad. Sci. USSR* (*Doklady Akad. Nauk SSSR*), Feb. 21, 1949, vol. 64, pp. 779–782.

The authors discuss the problem of elastic stability of structures subjected to suddenly applied constant forces. In particular, differential equations for the lateral displacement are presented for a pinned-pinned column subjected to a suddenly applied axial load and for a tube subjected to a suddenly applied external pressure. The load conditions under which these systems become elastically unstable are tabulated over a wide range of values corresponding to various forms of instability. The higher buckling modes were indicated by the buckled forms of a column and a tube subjected to explosion pressures in a test.

Walter W. Soroka, USA

1121. **W. Nowacki, "The bending of compressed continuous plate"** (in Polish), *Arch. Mech. stos.*, 1949, vol. 1, pp. 67–79.

The paper discusses the problem of simultaneous bending and compression of a rectangular plate freely supported along the perimeter and resting on several edge supports which divide the plate into sections. The following cases are considered: (1) a plate compressed by distributed forces acting parallel to the edges of the supports; (2) a plate compressed by distributed forces acting perpendicular to these edges; and (3) a plate supported along the perimeter and compressed by two concentrated and opposite forces. In the first two cases the plate is also bent by a distributed load and in the last one by a concentrated force.

The author takes the bending moments over the edges of the supports as the statically indeterminate quantities. He derives equations which correspond to the three-moment equations in continuous-beam theory. The starting point is a rectangular plate supported along the perimeter and loaded with moments along one of the edges. The integration of the differential equation of the plate is done by the use of power series. The author considers several particular cases, one of which is that of a plate fixed along one edge and freely supported along the other three, and loaded with distributed forces applied over the edge, parallel to the plane of the plate and acting at some distance from this plane.

W. Wierzbicki, Poland

1122. **Manuel Stein and Robert W. Fralich, "Critical shear stress of infinitely long, simply supported plate with transverse stiffeners,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1851, Apr. 1949, 39 pp.

The energy method is used to obtain solutions for the critical shear stress of an infinitely long, simply supported plate stiffened with equally spaced transverse stiffeners of zero torsional stiffness. Two general cases are studied: that of relatively flexible closely spaced stiffeners, and that of stiffeners having greater rigidity. In the first case it is assumed that the buckled pattern is independent of stiffener spacing, and the stiffener rigidity is therefore distributed uniformly over the panel, giving the effect of an orthotropic plate.

The second case is further subdivided into cases where buckling patterns are periodic over two and over four bays (since these lead to the lowest critical stresses) and the finite stiffener spacing thus affects the buckle pattern. Minimization of the potential energy, including the bending energy of the stiffeners, is accomplished by use of Lagrangian multipliers and leads to formation of a stability matrix. Buckling parameters are obtained by successive approximations, the process being stopped after two or three cycles. Using these solutions, numerical buckling coefficients are calculated for the entire range of stiffener relative rigidity and for several practical panel proportions. Comparison with previous theory indicates that the older methods give unconservative results for intermediate values of stiffener rigidity and conservative results for high rigidities.

John E. Goldberg, USA

1123. **Murry Schildcrout and Manuel Stein, "Critical axial-compressive stress of a curved rectangular panel with a central longitudinal stiffener,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1879, May 1949, 18 pp.

The critical axially compressive stress of a simply supported curved rectangular panel having a central longitudinal stiffener offering no torsional restraint is determined on the basis of small-deflection theory. For panels of small curvature, the stiffener does actually raise the critical load. For panels of large curvature, a method is suggested to correct for the large-deflection effects in lowering the critical load.

H. S. Tsien, USA

1124. **Richard A. Pride and George J. Heimerl, "Plastic buckling of simply supported compressed plates,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1817, Apr. 1949, 22 pp.

Local-instability tests were made on drawn square tubes of 14S-T6 aluminum alloy to determine the validity of various theories for the plastic buckling of simply supported plates. Excellent agreement appears to have been obtained with Stowell's unified theory [see same source, no. 1556] which is based upon deformation stress-strain relationships derived by Ilyushin, but assumes that unloading of plates does not occur during the early stages of plastic buckling. Good agreement (the theories being slightly unconservative) was also obtained with the deformation type theories of Bijlaard and of Ilyushin, and also with the empirical secant-modulus method. Poor correlation was obtained between test results and the Handelman-Prager flow-type theory for plastic buckling.

John E. Goldberg, USA

1125. **J. J. Stoker, "Pre-stressing a plane circular plate to stiffen it against buckling,"** *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 268–276.

Prestressing is obtained by cutting a radial slit in the circular plate, then inserting a wedge of small angle so as to open the plate fanwise, and finally welding the wedge to the plate. A uniform compressive stress is superposed upon the prestressed plate and the critical buckling value is determined. The analysis is based on linear buckling theory using the Rayleigh-Ritz procedure and considering a clamped plate.

It is found that, with proper choice of the wedge angle, the plate will not buckle until the compressive stresses are more than three times as large as required for buckling of an initially unstressed plate. The critical buckling pressure increases with the wedge angle up to a certain critical wedge angle beyond which

the buckling pressure is lowered. This phenomenon is shown to be due to the fact that, when the wedge angle exceeds a certain value, the buckling occurs in a nonsymmetric mode with several nodal diameters. By attaching concentric circular stiffening beams to strengthen the plate against buckling with nodal diameters, it is theoretically possible to increase the buckling stiffness indefinitely by increasing the wedge angle.

Dana Young, USA

1126. Georg Schmidt, "On the buckling strength of the upper chord of a bridge with a central girder" (in German), *Bautechnik*, Jan. 1949, vol. 26, pp. 10–13.

The upper chord of a bridge can be considered an elastically supported beam. Symmetric loading on both sides of the bridge leads to a stability problem of the chord. A load on one side of the bridge on the other hand leads to the problem of a beam loaded axially and laterally.

The author applies computation methods of Cornelius (Thesis, Darmstadt, 1944) and others to a special practical example, and finds that of the two loads mentioned, the case of the full load on both sides of the bridge is the more dangerous one.

W. L. Esmeijer, Holland

Joints and Joining Methods

(See also Rev. 1144)

1127. Artémy S. Joukoff, "Principles for the calculation of spot welded joints" (in French), *Ossature métallique*, Mar. 1947, vol. 12, pp. 138–149.

The author has measured the strength of single-spot welds joining two plates (lap joint) and three plates (load transmitted from middle plate to outside plates). The plates were steel, 1 to 8 mm thick. He derives from these tests design rules for static loading which he considers sufficiently simple for practical needs.

Henri M. Schnadt, Luxemburg

1128. W. F. Hess, W. J. Childs and R. F. Underhill, Jr., "Further studies in projection welding," *Weld. Res. Suppl.*, Jan. 1949, vol. 14, pp. 15–23.

The research reported in this paper is a continuation of previous work conducted at Rensselaer Polytechnic Institute in order to broaden the knowledge of projection welding and to establish optimum conditions. Weld time, weld current, electrode force, projection size and shape have been studied as variables.

M. Reiner, USA

1129. E. H. Mansfield, "Rivet flexibility and load diffusion," *Aircr. Engng.*, Apr. 1949, vol. 21, pp. 96–98, 116.

The stress distribution is examined in: (1) a sheet fastened along two parallel sides to bars of constant cross section, both subject at one end to tensile forces; (2) a sheet as under (1) except that the bars are tapered for constant tension; and (3) a bar fastened to a semi-infinite sheet, the bar as before subject to a tensile force.

A solution of the three problems is first obtained under the assumption that the sheet is stiffened by rigid transverse members so that transverse strains in the sheet may be neglected. A rigorous solution of the last problem is also given under the assumption of a stiff edge member which can produce shear in the sheet but no normal stress. Where prior investigations have led to solutions giving an infinite-peak shear stress at the free edge of the sheet adjacent to the bars, the author avoids this difficulty by stipulating a flexible connection between sheet and bars, equivalent to the elasticity of discrete rivets or spot welds at the junction. Under these conditions the peak shear stress remains finite. Tapering of the bars to reduce weight is shown to involve an increase in the peak shear stress. The author discusses the effect on the peak shear stress of changes in the area of the bars, the skin thickness, the number of rivets and the substitution of spot welds for rivets.

F. Hymans, USA

Structures

(See also Revs. 1122, 1126, 1174, 1177, 1199)

1130. A. Tenot, "Mechanics of rigid and deformable systems, vol. 5" (in French), Dunod, Paris, 1947. Paper, 8.9 × 5.6 in., 399 pp., 170 figs.

In the first part of the book statically determinate systems are treated. After a short exposition of the general laws of equilibrium, applications of these laws are demonstrated by means of numerous examples covering practical problems.

The second part deals with statically indeterminate systems and presents in detail the laws of Maxwell and Castigliano, and their applications to practical problems. The large number of examples contributes considerably to the explanation of these laws. Both analytical and graphical methods of solving statically indeterminate problems are illustrated. A special section treats problems relating to aircraft design.

The clear and precise way in which the laws and their applications are presented should make the book valuable to the student as well as to the practical engineer.

E. Haenni, USA

1131. John A. Van den Broek, "Theory of limit design," John Wiley and Sons, New York, 1948. Cloth, 5.6 × 8.6 in., 144 pp., 75 figs., $3.50.

In the first chapter (12 pages) the author discusses ductile properties of common structural materials, based on his own extensive tests on the effect of cold-working and aging on tensile and compressive properties, in the same direction as, in the opposite direction to and at right angles to, the direction of working. An interesting fact demonstrated is the important effect of aging after cold-working of mild steel, in bringing the proportional limit from a low initial value up to the yield point.

In the next three chapters (15, 34 and 65 pages) he develops the theory of limit design for simple beams, redundant beams and trusses, respectively. The latter chapter is largely concerned with the author's previously published, but unfortunately little publicized, work on the effects of initial shape imperfections and of yielding on column buckling; this includes data from his unusually careful column tests, which clearly demonstrate among other things the maintenance of constant resistance of slender columns with large axial deformation, and hence the applicability of limit design to structures containing such columns.

The fifth chapter (7 pages) contains a welcome discussion, again illustrated with the author's tests, of practical details of connection design which are conducive to ductility and hence to the applicability of limit design. A brief discussion of some of the limitations of limit design, and brief reference, problem and index sections complete the book.

The reviewer considers that the author has done engineers a great service in combating the naive but common acceptance of design based on elastic stress analysis for the many nearly statically loaded structures which are made of ductile materials, and in putting on a rational and practical basis the determination of the real useful strength of such structures. The author's demonstration that in common beam problems some 50 per

cent greater load than indicated by elastic analysis can actually be borne without exceeding elastic deflections indicates the importance of the subject. It is unfortunate if the controversial tone of many of the author's discussions and his numerous faults in presenting his ideas antagonize some readers. The reviewer finds his personal and informal style and unconventional ways of thinking refreshing and stimulating even if everything is not agreed with.

The reviewer would like to see more specific discussions of the limitations of this method, and of its many advantages, particularly in the possibilities for more efficient because more rational design. L. H. Donnell, USA

1132. C. P. Siess and N. M. Newmark, "Rational analysis and design of two-way concrete slabs," *J. Amer. Concr. Inst.*, Dec. 1948, vol. 20, pp. 273–315.

A new method is proposed for the design of two-way continuous building slabs over rigid beams. The procedure is one of "moment distribution" and is approximate, as it deals only with the average values of the bending moments which act along the sides of the panels. The accuracy of the distribution procedure is estimated by using it in the analysis of certain continuous slabs for which the correct moments are known. The error in the edge moments obtained for these cases by the approximate analysis is found to be about six per cent.

The paper includes an investigation of the effect of the side ratios of the panels, the presence of discontinuous edges, and the effect of torsional restraints by the supporting beams. It takes into account various combinations of loadings and panel ratios and makes recommendations for the incorporation of these factors in the design procedure. M. Hetényi, USA

1133. Vladimir Koloušek, "Static and dynamic calculation of stayed antenna masts" (in French with English and German summaries), *Publ. Int. Ass. Bridge Struct. Engng.*, 1947, vol. 8, pp. 105–140.

The author considers the strength, stability, and the free and forced vibration of stayed antenna masts. The paper contains no new contributions to the knowledge of the subject. A numerical example is worked out in great detail. P. C. Dunne, England

1134. W. Olszak, "Prestressing applied to bound columns," in English), *Arch. Mech. stos.*, 1949, vol. 1, pp. 80–98.

The idea of introducing initial compressive stresses into brittle materials when under bending or tension, is successfully employed in modern structural engineering. The author presents an interesting and somewhat unexpected extension of this idea to axially loaded, helically bound columns. The problem is solved as one of the theory of elasticity involving the analysis of a "transversally orthotropic" model. Initial prestressing of the spirals reduces the contraction as well as the lateral expansion of the concrete core, and raises the crushing load of the column, as based on the Caquot-Mohr criterion of rupture. The coefficients of increase in the crushing load are the higher: (a) the higher the quality of steel, (b) the lower the quality of concrete, (c) the higher the ratio of lateral compression to longitudinal compression. These effects are obtained with low and medium percentages of binding which generally occur in practical design. They do not apply to very lightly and very heavily bound columns.

The author's basic conclusions are in agreement with the results of experimental data obtained by G. A. Maney.

W. Wierzbicki, Poland

Rheology (Plastic, Viscoplastic Flow)

(See also Revs. 1118, 1124, 1131, 1146, 1148)

1135. R. von Mises, "Three remarks on the theory of the ideal plastic body," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 415–429.

Statements are frequently made in the current literature that the theory of perfect plasticity is unable to determine the boundary between the elastic and plastic regions. The present paper provides a refreshing antidote to such pessimism. Particular solutions are presented for torsion and for thick-walled tubes under pressure.

A new approach to the solution of plasticity problems is provided by the linearization of the fundamental equations. This new approach is illustrated by some problems in thick-walled tubes. Clarence Zener, USA

1136. Fritz Gassmann, "On small displacements in imperfectly elastic bodies" (in German), *Schweiz. Bauztg.*, Jan. 22, 1949, vol. 67, pp. 55–56.

The equations of motion are established for a type of continuum for which Hooke's law ($p = 3k\vartheta$) is replaced by $A(p) = B(\vartheta)$ where A and B are differential operators, namely, polynomials in d/dt. The various models of viscoelastic solids and liquids may be obtained as special cases of this type. The method of approach is illustrated by discussing two elementary types of vibrations in a semi-infinite body bounded by a plane.

M. Hetényi, USA

1137. Aris Phillips, "Calculation of the displacements in plastic torsion," *J. Math. Phys.*, Jan. 1949, vol. 27, pp. 270–273.

The plastic torsion of a prismatic bar is considered under the assumption that the material exhibits strain hardening. No restrictions are made with respect to the shape of the cross section.

The results are derived under the conditions that: (*a*) The principal axes of stress are always parallel to the principal axes of strain; (*b*) the figure consisting of the three principal strain circles of Mohr is always geometrically similar to the figure of the three stress circles of Mohr; (*c*) the material is incompressible; (*d*) the intensity of the strain deviation D_d is a known function of the intensity of the stress deviation T_d:

$$T_d = [(\sigma_x - \sigma_m)^2 + (\sigma_y - \sigma_m)^2 + (\sigma_z - \sigma_m)^2 + 2(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)]^{1/2},$$

$$\sigma_m = (\sigma_x + \sigma_y + \sigma_z)/3,$$

$$D_d = [\epsilon_x^2 + \epsilon_y^2 + \epsilon_z^2 + \tfrac{1}{2}(\gamma_{yx}^2 + \gamma_{yz}^2 + \gamma_{xy}^2)]^{1/2}.$$

C. B. Biezeno, Holland

1138. E. Siebel and S. Schwaigerer, "Stress calculations based on yield point limits" (in German), *Z. Ver. dtsch. Ing.*, Nov. 1948, vol. 90, pp. 335–341.

This paper presents a calculation procedure for the determination of stresses and strains beyond the elastic limit. It is assumed that the strain pattern may be predicted with sufficient accuracy by the theory of elasticity. The strains obtained in this way are then related to the stresses in the plastic region by the secant modulus. The secant modulus is determined by experiment. The necessary calculations are carried out, in part, graphically. The method is applied to rotating hollow cylinders, notched tension specimens, shafts in torsion and other examples.

Paul F. Chenea, USA

1139. George E. Griffith, "Experimental investigation of the effects of plastic flow in a tension panel with a circular hole," *Nat. adv. Comm. Aero. tech. Note*, no. 1705, Sept. 1948, 17 pp.

This paper deals with the experimental determination of plastic stresses, and their effect on factors of stress concentration, for the special case of a bar with a central circular hole subjected to uniform tension at the ends. The transverse stresses are known to be small in this case and have been neglected. Using precision strain gages, the author measured strains at a number of points across the transverse section through the hole during the loading and unloading cycles, for several peak loads. Of primary importance in each cycle were the maximum tensile strain at the hole, corresponding to the peak loads, and the residual strain at zero load.

After completing these measurements, coupons were cut from the corners of the panels, where the stresses were small, and subjected to uniform stresses. The loads on the coupons were adjusted to reproduce the maximum and the residual strains at the hole. It was found that in order to duplicate the residual strains in the panel the stresses in the coupon had to be compressive. The compressive stresses so obtained were taken as being equal to the plastic stress at the hole.

For the elastic range the author obtained a factor of stress concentration of 2.57. The corresponding value determined photoelastically by the reviewer [*Mech. Engng.*, Aug. 1936] is 2.47, giving a difference of 4 per cent. Even if a correction were made for the fact that the strain gage measured the average and not the maximum strain, the difference would only be about 6 per cent. The author's statement that the difference is only 2.7 per cent results from assuming a photoelastic factor of 2.5, which is high. This is, however, a minor point and in no way detracts from the value of the paper.

From the results obtained the author concludes that: (1) Within the elastic range, the theoretical and experimental results were in good agreement. (2) As the amount of plastic flow increased, the stress-concentration factor (based on the average net-section stress) decreased from 2.57 to 1.21 when the average net-section stress reached a value of 50,000 psi, while the strain-concentration factor increased from 2.57 to 7.10. (3) Within the experimental scatter, the test results were not changed in 100 cycles by repeating the loading cycles.

The paper contains some very instructive figures and diagrams.

M. M. Frocht, USA

1140. Hugh O'Neill, "Internal stresses in railway materials," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 337–349.

Nineteen examples of the occurrence of internal stresses in railway practice are outlined, in eight of which it is deliberately employed to play a useful part. Details are given regarding manufacturing stresses in various types of rail, and the effect of high-speed pounding by locomotives is considered. Values have been determined for the internal stress in peened piston rings, shot-blasted spring plates, boiler rivets, and expanded boiler tubes. Fatigue cracking in axle press-fits is outlined, and the shrink-fits of wheels and tires are considered in relation to thermal effects from braking and welding.

J. A. Haringx, Holland

1141. A. Latin, "Pressure and creep tests at constant hoop stress on lead and alloy 'E' pipes," *J. Inst. Metals*, Jan. 1948, vol. 74, pp. 259–289.

Long-time creep tests under constant stress were carried out on pipes of lead and lead alloy "E" (antimony 0.2, tin 0.4 per cent, the remainder lead), the stresses ranging from 400 to 800 psi for lead and from 800 to 1400 psi for alloy E. Comparison of experimental extension-time functions $\epsilon(t)$ with Andrade's equation $\epsilon(t) = (1 + \beta t^{1/3}) \exp kt - 1$ shows fair agreement. A plot is presented giving the dependence on stress of β and k. It is to be noted that the k values are such that the exponential function reduces to $1 + kt$, with an error not greater than 5 per cent. Andrade's formula then can be reduced to the approximate form $\beta t^{1/3} + kt$, the first term representing "transient" and the second term "permanent" flow. The β values by far exceed the k values; since the latter decrease much more strongly with decreasing stress than the former, at low stresses transient flow predominates over permanent flow.

The creep behavior, as characterized by the β and k curves, is similar for the two materials. The extension reached before failure is, at high stress, much greater for alloy E than for lead; at low stresses it is greatly reduced for the former, but not much influenced for the latter. The mode of fracture is different, being of the "creep" type for alloy E and of the "long-break" type for lead. A theoretical discussion is given, and the bearing of the results on the behavior of pressure-cable sheath is discussed.

B. Gross, Brazil

Failure, Mechanics of Solid State

(See also Revs. 1113, 1140, 1141, 1145, 1150, 1177)

1142. J. C. Fisher and J. H. Hollomon, "A statistical theory of fracture," *Trans. Amer. Inst. min. metall. Engrs.*, 1947, vol. 171, pp. 546–561.

This interesting paper attempts, using statistical analysis, to rationalize the size effect in solids, the scatter of fracture-stress values, and the dependence of fracture stress upon strain, and to suggest a quantitative relation between the structure and the fracture stress. The material is assumed to have an idealized structure, namely that of an elastic solid containing many cracks which are oriented at random and assumed to be thin and disk-like, with elliptic cross sections.

Some of the interesting conclusions are: (1) The scatter of fracture values is very small if the number of cracks is large. (2) There is a marked decrease in strength with increasing number of cracks, and no marked size effect should be expected in materials containing many cracks. (3) Triaxial tension causes a considerable decrease in strength over that for simple tension. (4) Compression in two directions perpendicular to a tensile stress slightly increases the value of the tensile stress for fracture. (5) The fracture stress in the direction of deformation increases with deformation, while the stress for lateral fracture decreases.

Henri M. Schnadt, Luxemburg

1143. U. R. Evans, "Influence of residual stress on chemical behaviour," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 291–310.

An interesting method has been developed for separating oxide-films from nickel by transferring them to a vaseline base. In this state the thicker films show wrinkles, which is consistent with the existence of a uniform compression stress in the film due to expansion of the metal in oxidizing. The thinner films, on the other hand, curl into rolls to an extent dependent upon the prior surface treatment. This suggests a stress gradient inherited from residual stresses in the metal surface.

Whereas corrosion-fatigue cracking (usually transgranular) can be brought about in almost any material in a corrosive medium, stress-corrosion cracking (usually intergranular) is shown by materials only under certain critical conditions. The effect of residual stresses upon corrosion appears to be connected with film

breakdown. Thermal stress relief and peening may reduce susceptibility to corrosion; under certain conditions, however, it makes matters worse. J. A. Haringx, Holland

1144. **R. D. Stout and L. J. McGeady, "Notch sensitivity of welded steel plate,"** *Weld. Res. Suppl.*, Jan. 1949, vol. 14, pp. 1–9.

This paper reports on tests carried out on a number of structural steels to determine the modification in properties of steel plates produced by welding, mechanical treatment and heat treatment. A longitudinal-notch bend test under static loading was used to show the effects on fracture transition temperature and ductility transition temperature of such factors as chemical composition, plate thickness, welding, heat treatment, and strain aging. A study was made of the factors influencing the origin of crack formation and of the effect of normalizing temperature on prime plate and subsequently welded plate. Initial cracking appeared in either prime or welded plate at relatively small angles of bend. Steels containing about 0.18 per cent C cracked first in the weld metal, whereas steels of higher alloy or carbon content were found to form cracks in the heated zone of the plate metal. Normalizing at the proper temperature was shown to improve the fracture transition temperature and the ductility transition temperature; higher or lower normalizing temperatures were deleterious.

In numerous instances contrasting results were indicated by ductility measurements as compared with the trends indicated by cleavage fracture transition temperatures. Actually it is not known whether strength, ductility, energy absorption, mode of fracture of some other property are of significance in appraising service performance. The authors present a rather refreshing discussion in which they question the relative significance of ductility measurements versus brittle fracture transition measurements, and point out that no clear-cut choice can be made between these criteria as measures of service performance. Until information can be collected which will define the exact properties controlling the serviceability of steel, there can be no final answer to the problem. Examination of satisfactory and unsatisfactory plates in service is suggested as a means of providing the information needed for a more accurate appraisal of the value of fracture, or of ductile transition measurements as made in the laboratory. T. J. Dolan, USA

Design Factors, Meaning of Material Tests

(See also Revs. 1127, 1128, 1131, 1144, 1146)

1145. **C. J. Osborn, A. F. Scotchbrook, R. D. Stout and B. G. Johnston, "Comparison of notch tests and brittleness criteria,"** *Weld. Res. Suppl.*, Jan. 1949, vol. 14, pp. 24–34.

The investigation was designed to provide a comparison between various methods of determining inherent brittleness in steels. It was considered that a test involving the slow loading of notched specimens was preferable to the Charpy test, and three such methods were selected for the determination of the transition temperature: the Kahn tear test, the Penn State slow notched bend test, and the Lehigh slow notched bend test.

The criteria of brittleness were made the same in all three tests where possible, and included: (1) the percentage of the fracture area which exhibits a cleavage type of fracture; (2) the energy absorbed by the specimen after passing the maximum load until the load had fallen off to half maximum; (3) the percentage contraction in the width of the specimen at a point $^1/_{32}$ in. below the notch after fracture; (4) the percentage reduction in width at the midpoint of the specimen (taken $^1/_{32}$ in. below the drill hole in the Penn State specimen); (5) the bend angle at maximum load in the Lehigh test, the bend deflection at maximum load in the Penn State test, and the percentage elongation on a 2-in-gage length, $^1/_4$ in. behind the notch for the Kahn test.

Various curves are drawn for two steels, ASTM A70 and A201, in the conditions: as rolled, after 10 per cent plastic strain, and strained by 10 per cent and annealed for 2 hours at 200 C. The results showed that each of the three tests distinguishes two different transition temperatures T_B and T_N separated by about 100 to 200 C. For instance in the Lehigh test, T_N is shown by the fracture appearance and the energy after maximum load, and T_B by the bend angle at maximum load and the percentage contraction below the notch. It is considered that T_N is the temperature of transition from a shear to a cleavage mode of fracture under the stress conditions imposed by the machined notch, and T_B is the transition temperature for the stress conditions at the base of a sharp crack formed by shear fracture immediately below the notch (and is therefore characteristic of deformed metal).

An explanation is given for the differences in the transition temperature ranges as shown by the three tests. The Lehigh method of test was considered to be the most satisfactory in view of its simplicity, speed and reliability of determining both T_N and T_B. B. W. Mott, England

Material Test Techniques

(See also Revs. 1114, 1145, 1149, 1150, 1219)

1146. **James B. Duke, "Some characteristics of residual stress fields during dynamic stressing above the endurance limit,"** *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 755–766.

While the title of this paper does not indicate it, the novel feature for the use of the DuMont cyclograph is connected with the prediction of fatigue failures before rupture occurs. The discussion of this paper is particularly fruitful in pointing out the practical significance and possible value of the use of this kind of an instrument. R. G. Sturm, USA

1147. **Dietrich G. Stechert, "Study of A.S.T.M. tentative stiffness test as applied to rubber,"** *Amer. Soc. Test. Mat. Bull.*, no. 157, Mar. 1949, pp. 61–65.

This paper considers the analytical basis for an ASTM test (D747-43T) for flexural stiffness of very flexible plastics such as rubber. This test method utilizes a simple cantilever beam and the concept "stiffness in flexure" E' as defined by

$$E' = pWb/(3\theta I),$$

where b is the beam length, I the moment of inertia of the cross section and θ the angle between the initial center line of the beam and a line connecting the free and fixed ends of the deflected beam. The values of p and W are read from the testing machine, their product being the moment applied to the fixed end of the beam.

The author derives a differential equation for the elastic curve of a cantilever beam with large deflections by assuming that Hooke's law holds and that the elastic axis passes through the centroids of cross sections, and obtains the solution

$$E = pWb/(NI),$$

where E is the Young's modulus and N is a function of θ. The discrepancy between N and 3θ is less than 10 per cent when θ is less than 30 deg, but increases to more than 100 per cent when θ is 90 deg. A number of tests of rubber cantilever beams were made, and values of E computed from the last equation are presented. The large variations found in the computed values of

E lead to the conclusion that this method is not useful as a fundamental measure of the elastic properties of rubber.

Charles E. Crede, USA

Mechanical Properties of Specific Materials

(See also Revs. 1128, 1141, 1144, 1145, 1146)

1148. W. Betteridge, "The relief of internal stresses in aluminum alloys by cold working," *Inst. Metals Monogr. Rep. Ser.*, no. 5, 1948, pp. 171–177.

According to the author the internal stresses in high-strength aluminum alloys, which result from the quench following solution-treatment, can be considerably reduced by a slight amount of cold work. This work may be applied either by pressing or stamping, preferably between the solution-treatment and aging. The final mechanical properties are much better than those obtained by quenching the material in boiling water, the method usually followed to reduce the internal stresses.

J. A. Haringx, Holland

1149. John C. McDonald, "Tensile, creep and fatigue properties at elevated temperatures of some magnesium-base alloys," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 737–754.

This paper presents the results of more or less standard creep and fatigue tests on a few magnesium alloys. These data, while presented in the conventional manner, will be very useful to a designer of magnesium parts, particularly magnesium pistons. No special study need be made of the results in order to compare them with other similar results on other materials.

R. G. Sturm, USA

1150. A. A. Moore, "The effect of speed of testing on magnesium-base alloys," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 1133–1138.

The results of a series of tension and compression tests at various speeds on magnesium-base alloys are reported. It is shown that the tensile strength and percentage elongation change very little in the normally used range employed in tension testing. At very low rates of straining the yield strength was lowered, whereas at high rates it remained unaffected.

S. K. Ghaswala, India

1151. J. W. Freeman, Howard C. Cross, E. E. Reynolds, and Ward F. Simmons, "High-temperature properties of rotor disks for gas turbines as affected by variables in processing," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 555–590.

This paper presents the most comprehensive data available to date on properties of large forgings of heat-resisting alloys, and the effects on them of working and heat treatment. Twenty-four disks of eight different alloys were tested as hot forged, hot-cold worked, solution treated, and solution treated and aged. Short-time tensile, rupture, creep, and stress-time for total deformation characteristics were determined at temperatures of 1200, 1350, and 1500 F. Hot-cold-worked or as-forged materials were superior at the lower temperatures, whereas solution-treated and aged materials were best at the higher temperatures. Tensile properties showed no consistent correlation with time-dependent properties. Properties of bar stock are similar to properties at the rims of the large forgings.

Both high and low-alloyed materials were investigated. Inconel X did not conform exactly to the generalizations stated for the other alloys.

A. R. Bobrowsky, USA

Hydraulics; Cavitation; Transport

(See also Revs. 1107, 1154, 1156)

1152. L. Escande, "Supplementary problems of hydraulics, part I" (in French), Edouard Privat, Toulouse, 1947. Paper, 9.5 × 7.5 in., 220 pp., 160 figs.

In a type of publication found more commonly in European than American technical literature, the author has presented analytical or experimental solutions of a series of unrelated problems illustrating new applications of hydraulics principles. The 11 chapters cover investigations of re-entrant tubes, open-channel inlets and miter bends, air entrainment in closed conduits, resistance of grids, vortex formation above conduit inlets, broad-crested weirs, recovery of head at conduit outlets, closure of butterfly valves, water hammer, and miscellaneous short problems. The projects described were conducted under the author's direction at the Fluid Mechanics Institute of the University of Toulouse, and represent in large part problems submitted by the industry. The book contains a brief preface by C. Camichel, founder of the Institute.

Hunter Rouse, USA

Incompressible Flow: Laminar; Viscous

(See also Revs. 1169, 1172, 1192, 1218)

1153. Marcel Tournier and Marc Bassière, "Vortex motion in transient state" (in French), *Off. nat. Étud. Rech. aéro. Rep.*, no. 16, 1948, pp. 1–42.

The paper presents an application of the Laplace transform to the determination of unsteady motion of an incompressible viscous fluid in the following cases: (*a*) the fluid flows between a fixed and a uniformly moving plane; (*b*) the fluid is in the interior of a rotating cylinder; (*c*) the fluid is between two rotating coaxial cylinders; (*d*) a rotating cylinder in an undefined fluid. In all these problems the equations of Stokes-Navier assume a linear form.

Carlo Ferrari, Italy

1154. H. F. P. Purday, "Streamline flow," Constable & Co., London, 1949. Cloth, 8.75 × 5.5 in., 185 pp., 79 figs., approx. $3.60.

The subtitle of the book, "An introduction to the mechanics of viscous flow film, lubrication, the flow of heat by conduction, and heat transfer by convection," gives a complete description of its content. With emphasis on nonturbulent flow, the author shows the close relationship between fluid flow and heat transfer, with regard to their physical and mathematical aspects, and in engineering applications. The mathematical developments assume knowledge of calculus, and include illustrations of the use of the Gamma function, the integration of differential equations in series and by numerical methods, etc. The examples given in form of tables of numerical computations show the work required for complete solutions.

The engineering applications include viscous resistance in tubes and channels, resistance of solid bodies in motion through viscous fluid, a treatment of film lubrication of sliding pads and journal bearings, heat flow in exchangers and in the cylinders and pistons of internal-combustion engines. The book is written for the student and for the practical engineer working in design and applied-mechanics research. Its main asset lies in the combined treatment of fluid flow and heat transfer in a concise form filling the gap between elementary and more advanced presentation and in collecting, for convenient study and use, material otherwise widely scattered over the technical literature.

Otmar E. Teichmann, USA

1155. **C. Truesdell, "The effect of viscosity on circulation,"** *J. Met.*, Feb. 1949, vol. 6, pp. 61–62.

The connection between the change of circulation along a closed fluid line in a viscous compressible fluid and generation of vorticity in a flow, is treated. After establishing the general equations, the author takes up some important special cases:

(1) Nonviscous, incompressible fluid. Vorticity could be created only by nonconservative external force system (Kelvin).

(2) Constant viscosity incompressible fluid. Vorticity cannot be created; it can only be redistributed by the action of viscosity in the absence of external nonconservative force system.

(3) Compressible fluid with constant viscosity with only conservative external forces present. The rate of generation of vorticity is proportional to the vector product of the gradients of the pressure and density.

(4) Nonuniform viscosity in incompressible fluid. Vorticity can be created by the inhomogeneities of the viscosity and

$$D\Gamma/Dt = 2\alpha \oint \text{grad } \mu \cdot d\bar{v}$$

where Γ is the circulation, D the symbol of material differentiation $\alpha = 1/\rho$, μ the viscosity, and $\bar{v}$ the velocity vector.

Finally, a comparison of results for fixed and rotating coordinate systems is given.

Leslie S. G. Kovasznay, USA

1156. **Hunter Rouse and M. M. Hassan, "Cavitation-free inlets and contractions,"** *Mech. Engng.*, Mar. 1949, vol. 71, pp. 213–216.

The use of the analogy between the flow of electric current in a wedge of uniform electrolyte and the irrotational, axisymmetric flow of an incompressible fluid, to facilitate the design of conduit inlets and contractions, is described. If the boundary of the wedge is geometrically similar to the conduit profile, the analogy yields values of the pressure at the conduit wall from measurements of the electric resistance between points along the wedge boundary. A family of elliptic-arc inlet profiles and a family of cubical-arc contraction profiles were studied to obtain cavitation-free designs, that is, flows with no local pressure minima along the conduit wall. Stephen H. Crandall, England

1157. **R. M. Drake, Jr., "Investigation of the variation of point unit heat-transfer coefficients for laminar flow over an inclined flat plate,"** *J. appl. Mech.*, Mar. 1949, vol. 16, pp. 1–8.

This paper furnishes local heat-transfer coefficients for a flat plate inclined to the air stream. The experimental apparatus is so designed that the plate is not adiabatic, but emits a constant amount of heat per unit area over its entire surface. Data for the laminar boundary-layer regime are correlated by a conventional power-law Nusselt-Reynolds number formula. However, much of the data reported is within, or beyond, the transition zone, and is useless for this particular correlation, which, in the reviewer's opinion, should be substantiated by further measurements.

Harold G. Elrod, Jr., USA

1158. **Bernhard Haurwitz, "The effect of ocean currents on internal waves,"** *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 217–228.

Internal waves occur at the boundary of two fluid layers of different density. The theoretical investigations known up to now assume that the mean velocity of each layer is zero, an assumption which does not hold at all if ocean currents are present. In order to study the effect of a basic current on the internal wave motion the author considers a very simple model consisting of two fluid layers, each having constant density and velocity. The effects of viscosity are entirely neglected, a rather stringent restriction if one remembers the important effect of viscosity on the formation of surface waves by the wind. The author shows that, while the wave velocity is modified by the existence of such a current, the distribution of the vertical amplitude of the wave motion as a function of the depth is very little affected by the presence of an ocean current. The amplitude of the horizontal motion is modified to a certain extent by the presence of ocean currents.

Walter Wuest, Germany

Compressible Flow, Gas Dynamics

(See also Revs. 1155, 1169, 1178, 1181, 1197)

1159. **Jacques Nicolas, "Note on the properties of air used in propulsion at supersonic velocity"** (in French), *Rech. aéro. Paris*, Mar.-Apr. 1949, no. 8, pp. 43–52.

This paper is concerned with the effect of the temperature-dependence of the specific heats of air upon the pressure-temperature-Mach number relationships in compressible flow, including the isentropic case and normal and oblique shocks. Formulas, tables, and curves are given; all results are put in the form of corrections to the values which would apply if the specific heats were constant. Data cover Mach numbers to 3 and static temperatures 200 K to 288 K. Philip Rudnick, USA

1160. **Paul Germain and Roger Bader, "A study of some harmonic oscillations by means of a correspondence with homogeneous motions"** (in French), *C. R. Acad. Sci. Paris*, Apr. 4, 1949, vol. 228, pp. 1201–1202.

The perturbation potential ϕ produced by a harmonically oscillating wing moving with a uniform velocity V satisfies the equation

$$\phi_{xx} - \beta^{-2}(\phi_{yy} + \phi_{zz}) + k^2\phi = 0$$

where $\beta^2 = M^2 - 1$ and $k = (\omega/V)(\beta \sin\alpha/\cos^2\alpha)$. Here M, α and ω are, respectively, the Mach number, the Mach angle and the angular velocity of the oscillation.

For a given plan form with no angle of attack, the solution of the boundary-value problem is briefly outlined. If ϕ' is a solution for $k = 0$ of the form $\Sigma x^n H_n$, H_n being a homogeneous function, then the corresponding solution for $k \neq 0$ is $\phi = \Sigma x^n H_n F_{n+1/2}(2k^2u)$ where $u = \frac{1}{2}[x^2 - \beta^2(y^2 + z^2)]$, and F is a Bessel function.

Outside the wing $\phi = 0$ corresponds with $\phi' = 0$ for $z = 0$, and on the wing, for $z = 0$, $\phi_z = \Sigma \phi'_z F_{n+1/2}(2k^2u)$. With the aid of the known identity for Bessel functions,

$$\exp(ihs\sigma) = (2\pi)^{1/2} \Sigma(n + \tfrac{1}{2}) i^n J_{n+1/2}(hs)(hs)^{-1/2} P_n(\sigma),$$

an expansion for ϕ_z can be obtained for $z = 0$, since $F_{n+1/2}(t)$ is proportional to $t^{-n-1/2}J_{n+1/2}(t)$. It seems to the reviewer that the term $(2M^2/V)\phi_{xt}$ was assumed to be unimportant and neglected by the author. Y. H. Kuo, USA

1161. **K. Gottfried Guderley, "Singularities at the sonic velocity,"** *Hdqtrs. Air Mat. Comm. Dayton Tech. Rep.*, no. F-TR-1171-ND, June 1948, 118 pp.

The present paper is concerned with the study of a certain class of particular solutions which contain a singularity at the sonic velocity in the hodograph plane. With the use of these particular solutions, it is found that a great number of two-dimensional transonic flow questions can be investigated, the main application

being the treatment of the flow over a closed body with the free-stream Mach number equal to one. The results of the present paper are especially important in the above application, inasmuch as the usual methods such as the Prandtl-Glauert or the various hodograph methods either fail or become too cumbersome as the free-stream velocity approaches the sonic velocity.

The discussion of the singularities is based upon the hodograph equation simplified by means of the transonic law of similarity, in terms of the stream function, to the Tricomi equation

$$\psi_{\eta\eta} - \eta\psi_{\theta\theta} = 0.$$

Here θ is the angle of the velocity vector with the horizontal space axis, and η is essentially the difference of the velocity from the sonic speed. The particular solutions are then defined by the hypothesis

$$\psi(\eta, \theta) = |\eta|^n f(\zeta)$$

where $\zeta = 9\theta^2/4\eta^3$, n is a certain parameter which is determined from the physical conditions of the flow, and $f(\zeta)$ is a hypergeometric function for which explicit formulas are derived.

The most interesting application of the above singularities is the discussion of the flow over a body at zero angle of attack and with the free-stream Mach number equal to one. (Here the singularity corresponds to the point in the hodograph plane representing the free-stream velocity vector.) The allowable values of the parameter n (representing a singularity in the hodograph plane) are then found from the condition that the stream function is antisymmetric with respect to the θ-axis and that along the characteristics emanating from the singularity the stream function is represented by an analytic function. These conditions are sufficient to restrict the choice of n to the values $n = -5/2 - 3k$, k being a positive integer. Of this family of values only that for $k = 0$ is permitted to represent the "basic" singularity, since the use of other values alone will result in a physical plane consisting of more than one Riemann sheet. In order to obtain a body in the physical plane with a cusped nose, the author then superimposes an additional particular solution given for the value of $n = 0.5$. The pressure distribution and the drag coefficient are then computed, using the above representation of the stream function.

Other applications include the discussion of the singularity (in the hodograph plane) occurring at the throat of a Laval nozzle, and the analysis of a sonic free jet.

It might be mentioned finally that among the minor details of the paper there is a derivation of the simplified equation (the Tricomi equation) which shows a method by which one may correlate the particular solutions of the simplified equation with those of the exact hodograph equations. Hideo Yoshihara, USA

1162. S. Bergman, "On tables for the determination of transonic flow patterns," *Reissner Anniv. Vol.*, J. W. Edwards, Ann Arbor, 1949, pp. 13–36.

This paper is concerned with the formulation of tables of functions intended for use in the determination of transonic streamline patterns in the hodograph plane and in the transformation of such patterns to the physical plane. To illustrate the general principles involved, the preparation of analogous tables for the flow of an incompressible fluid is discussed first. These principles are then extended to the case of a compressible fluid by the use of a simplified hodograph equation (the Tricomi equation) and the introduction of a correspondence principle relating the incompressible flow around a given profile with the compressible flow around a distorted profile.

Two alternative methods are outlined for setting up the resulting tables, and a sample table is presented. The application of this table is illustrated by the calculation of a distorted transonic profile corresponding to the incompressible flow around a particular ellipse. A discussion is also included of the conditions under which a given hodograph pattern corresponds to a physically possible flow. Walter G. Vincenti, USA

1163. M. J. Lighthill, "Methods for predicting phenomena in the high-speed flow of gases," *J. aero. Sci.*, Feb. 1949, vol. 16, pp. 69–83.

The paper gives a very comprehensive and concise discussion of the present status of the theory of the dynamics of compressible fluid. A short discussion of the foundations of the subject and the boundary layer is followed by the main body of the paper dealing largely with isentropic flows. Discussion of problems involving shocks is limited.

Perturbations methods are discussed in great detail, especially the linearized theory. The Prandtl-Glauert rule for two-dimensional and axisymmetric flows are discussed, but the simpler Prandtl-Glauert rule applicable to general three-dimensional flows is omitted. Much of the recent progress in linearized theory of supersonic flow is reviewed, including its application to channels, slender bodies of revolution, general slender bodies, quasi-cylindrical ducts, and three-dimensional wings, Busemann's conefield theory and a brief discussion of unsteady flow problems. Here the author gives valuable accounts of recent literature, especially the British (some not yet published). References to other publications are not as complete. Some of the statements based on unpublished British papers are not clear to the reviewer; for instance, the discussion of the order of approximation of the theories dealing with slender bodies of revolution.

Nonlinear transonic approximation is only briefly mentioned, and it is stated that "its value is uncertain, since velocity variations are known to be great (however thin the body) at transonic speeds." The exact implication of this statement is debatable. Approximation in the hypersonic range is not discussed.

The application of the theory of characteristics is then discussed, and the paper is concluded by a discussion of the hodograph method. Recent improvements in the approximate method are not mentioned. In connection with the exact solutions, references are made to the work of Bergman, Cherry, and the author himself; the earlier work of Tsien and Kuo is not mentioned in the text. The objections raised by the author against their work are still under discussion [*J. aero. Sci.*, 1949, vol. 16, p. 189]. C. C. Lin, USA

1164. Kuno Foelsch, "The analytical design of an axially symmetric Laval nozzle for a parallel and uniform jet," *J. aero. Sci.*, Mar. 1949, vol. 16, pp. 161–166, 188.

In 1946, the author presented a paper at the Jet Propulsion Laboratory, California Institute of Technology Symposium, which described an analytical method of designing two-dimensional wind-tunnel nozzles. In the present paper the work is extended to the case of axisymmetric nozzles. In cross section, the nozzles of the present paper consist of circular arc sections at the throat, a straight-line segment forming a conical portion, followed by a transition curve to give parallel uniform flow. The conical position is expected to be sufficiently long to establish source flow. The analysis for the circular-arc throat selects its dimensions so as to obtain proper mass flow. The principal portion of the analysis of the paper is devoted to integrating the flow equation to obtain the transition curve which gives parallel flow. This is done approximately by observing that the inclination and magnitude of the velocity vary little along a characteristic, and the equations are linearized for integration along the characteristics. A second

integral is obtained from the conservation of mass, as was done in the earlier paper. An explicit set of instructions is given for constructing nozzles by this method. F. H. Clauser, USA

1165. **T. M. Cherry, "Flow of a compressible fluid about a cylinder,"** *Proc. roy. Soc. Lond. Ser. A*, Feb. 22, 1949, vol. 196, pp. 1–31.

The two-dimensional, isentropic, circulatory flow of a gas past a cylindrical obstacle is constructed using the hodograph method. A generating function which is related to the hodograph representation of a "corresponding" incompressible flow is introduced, and its series representation is generalized to represent a compressible flow, i.e., powers of the velocity are replaced by appropriate hypergeometric functions [see also Rev. **1513**, Oct. 1948]. The resulting functions are multivalued and further modification is needed. The correction functions are found as double series of hypergeometric functions. A lengthy discussion of the continuation of the solution into the various domains in the plane of the (complex) independent variable is required. The coefficients in the expansions are given explicitly but no numerical results are quoted. It is noted that the equations obtained are less convenient for computational purposes than those of Lighthill, but that the present solution (unlike Lighthill's) is appropriate for flows having two or more stagnation points within a finite region, e.g., flows past a noncuspidal obstacle. George Carrier, USA

1166. **T. M. Cherry, "Numerical solutions for transonic flow,"** *Proc. roy. Soc. Lond. Ser. A*, Feb. 22, 1949, vol. 196, pp. 32–36.

The streamlines and isobars of a noncirculatory transonic gas flow past a cylindrical obstacle are drawn. The computational details and theory are given only by reference.
George Carrier, USA

1167. **P. A. Lagerstrom and Martha E. Graham, "Linearized theory of supersonic control surfaces,"** *J. aero. Sci.*, Jan. 1949, vol. 16, pp. 31–34.

In this paper pressure distributions on control surfaces, as induced by the deflection of the surfaces, are computed by a linear theory. From these pressure distributions, the lift and center of pressure are computed. It is found that the interference between control surface and wing is very small, and is moreover, favorable. It is expected, however, that the linear theory may give values of lift and wave drag that are too high, and that the Reynolds number may be significant. The present paper is simply an abbreviated version of Douglas Report No. SM-13060, July 1947, by the same authors, which contains explanations, computations, and some discussion of the applicability of the theory to real fluids.
Charles Concordia, USA

1168. **M. F. Hoare and J. W. Linnett, "The mechanism of flame propagation,"** *J. chem. Phys.*, Aug. 1948, vol. 16, pp. 747–749.

One of the major problems in combustion is whether flames are propagated by the diffusion of free radicals, that is, by a hydrodynamical effect, or whether the rate of propagation of flames is controlled by the individual rates of chemical reactions.

Recently Tanford and Pease have shown that in a number of carbon-monoxide flames the burning velocity increases as the calculated equilibrium concentration of hydrogen atoms in the flame front increases. They point out that this would be so if the propagation of the flame were dependent on the diffusion of hydrogen atoms ahead of the flame. It is shown in the present paper that, by combining calculated ignition and flame temperatures, the variation in burning velocity with composition can also be accounted for on an essentially thermal theory of flame propagation. Thus, the problem is left wide open.
J. O. Hirschfelder, USA

Turbulence, Boundary Layer, etc.

(See also Revs. 1155, 1157, 1190)

1169. **W. W. Cope and D. R. Hartree, "The laminar boundary layer in compressible flow,"** *Phil. Trans. roy. Soc. Lond. Ser. A*, no. 827, June 22, 1948, vol. 241, pp. 1–69.

The paper refers closely to Goldstein's *Modern developments in fluid dynamics*. The authors state in their abstract that in part I the boundary-layer equations for a compressible fluid are derived, reduced to nondimensional form, and their relation to the corresponding equations for an incompressible fluid discussed. Methods of integrating them are considered and it is shown that, provided there is no pressure gradient in the main stream, the methods employed for incompressible flow are of practical value. If there is a pressure gradient, then the complications introduced by compressibility are such that general algebra must cease and numerical integration take its place at an early stage. This means that approximate methods (such as Pohlhausen's) of calculating separation lose their simplicity, and there are indications that their accuracy will also suffer; so it is natural to consider the practicability of direct integration of the equations, probably by series expansions.

In part II, suitable expansions in one independent variable with coefficients which are functions of the other are obtained. It is found that the independent variables can be so chosen that the differential equations for the coefficients in the expansions have the same general structure as for an incompressible fluid. The boundary conditions and the limiting forms of the equations for zero Mach number are investigated. The application of iterative methods to the equations is discussed.

In part III the ENIAC is briefly described, and the methods of applying it to obtain solutions of the equations derived in part II are described in some detail. It is shown that, by proper choice of independent variable, the results for zero-pressure gradient can be put in a form in which they vary only slowly with the square of the free-stream Mach number M. Linear interpolation in M^2 between the tabulated values will thus provide reliable first estimates of these quantities, and the accuracy can be improved, if required, by an iterative process. Tables of results are given. W. Spannhake, USA

1170. **N. A. V. Piercy, L. G. Whitehead and R. A. Tyler, "The laminar boundary layer,"** *Aircr. Engng.*, Dec. 1948, vol. 20, pp. 354–359.

The paper describes new solutions of the equations of incompressible flow in the laminar boundary layer. Two solutions are described; one is a series applicable to the flow over the front portion of a symmetric round-nosed body, the other is an approximate method applicable up to the separation point. In the second method, the expression representing the velocity within the boundary layer includes (1) the first two terms of the solution which holds over the front portion, and (2) two functions which, when properly chosen, represent an exact solution for two particular cases of boundary-layer flow. Two constants in the solution are determined by substituting in the von Kármán integral relation and in an equation obtained by integrating twice through

the boundary layer. Good agreement is shown with known solutions by Falkner and Skau, Howarth, and Hartree.

Arnold M. Kuethe, USA

1171. G. Viguier, "A few remarks on the Prandtl boundary layer; its equation in the case of large velocity gradients" (in French), *Rech. aéro. Paris*, Jan. 1948, no. 1, pp. 7–9.

This paper considers the fluid boundary layer under the condition that there are large velocity gradients, so that the relation between viscosity forces and velocity gradients cannot be assumed to be linear. The fluid is incompressible. General equations are derived utilizing the author's constants: D (a coefficient of viscosity) and T (dimensionless) defined in his previous works. A special case is shown to agree with the equation solved by D. R. Hartree by means of the differential analyzer.

Charles Concordia, USA

1172. W. Pfenninger, "Experiments on a laminar suction airfoil of 17 per cent thickness," *J. aero. Sci.*, Apr. 1949, vol. 16, pp. 227–236.

The author's experiments were carried out in the 7-by-10-ft wind tunnel of the Institute for Aerodynamics in Zurich. Continuous suction was not provided, but 24 and 16 suction slots were fitted on the upper and lower surface of the laminar wing, respectively. The suction slots were formed as diffusors and bent backwards, and their width could be varied. Also a 0.108-chord trailing-edge flap was fitted. The quantity of air sucked away from the boundary layer could be measured by special calibrated nozzles.

The measurements of the profile drag with and without suction showed the expected decrease with increasing Reynolds numbers, but the minimum value (0.0023) with boundary-layer suction was about one half the value without suction and occurred a little later, for a Reynolds number of 2.4×10^6, as against 2.0×10^6 without suction. The profile drag with suction also includes the equivalent drag due to the power of the suction fans.

Observations were made with a stethoscope showing that the boundary layer could be kept completely laminar on both sides of the wing with low suction quantities and within a considerable range of lift coefficients. For this range the drag coefficient could be kept at low values, giving very small gliding angles of the order 1/200, or even smaller, for various flap angles and Reynolds numbers. Finally the pressure distributions are plotted for different values of lift coefficient and flap angle. At the optimum lift coefficient the pressure distribution is uniform on both surfaces up to two thirds of the chord.

P. N. Brandt-Møller, Denmark

Aerodynamics of Flight; Wind Forces

(See also Revs. 1133, 1167, 1172, 1180, 1188, 1197)

1173. Committee on Guided Missiles of the Research and Development Board of the National Military Establishment, "Dictionary of guided missile terms," Public Affairs Press, Washington, 1949. Paper, 8.3 × 5.3 in., 57 pp., $2.

This dictionary, issued in co-operation with the *Antiaircraft Journal*, is an outgrowth of a monograph compiled by John A. White at the Applied Physics Laboratory, Johns Hopkins University. It seems to be aimed mostly at the nontechnical reader, although certain definitions may be welcome to the research worker. Ed.

1174. G. Ernst and M. Kramer, "Development of spoiler controls for remote control of flying missiles," *Nat. adv. Comm. Aero. tech. Memo.*, no. 1210, Mar. 1949, 42 pp. (transl. from *Zent. wiss. Berichtswesen Berlin Forschungsber.*, no. 1717, Jan 6, 1943).

Design and development of spoiler controls for guided missiles are presented, including details of aerodynamics, structures, and servomodels. Spoiler control consists of controllable air vanes judiciously located on the airfoil. The aerodynamic control forces are due to the separation of flow induced by the spoilers. The spoilers are actuated by an on-off type magnetic motor. The vane is made to vibrate between two positions, resulting in approximately proportional control. Six identical vanes mounted on the tail were used to provide three-axis control.

Wind-tunnel tests, flight test results, design and construction details are presented. The system performed up to Mach number 0.9. There is no indication that the spoilers will be effective at supersonic speeds. Flight testing was performed on a 3000-lb German guided missile. Some aerodynamic difficulty was experienced at high Mach numbers, and was solved by increasing the airfoil trailing edge thickness and thereby reducing the boundary layer, and also by projecting the spoiler from a faired "step" which eliminated the dead spot at low deflections.

Andrew Vazsonyi, USA

1175. Arthur W. Carter and Irving Weinstein, "Effect of forebody warp on the hydrodynamic qualities of a hypothetical flying boat having a hull length-beam ratio of 15," *Nat. adv. Comm. Aero. tech. Note*, no. 1828, Mar. 1949, pp. 1–47.

The effect of forebody warp (progressive increase of dead rise of the planing surface from step to bow) was investigated by tests in Langley Tank No. 1 of a large flying-boat model with slender hull (length-beam ratio 15) proportioned for advanced requirements of speed and range.

Takeoff and landing performance, longitudinal stability and spray characteristics were determined in smooth water and in waves.

Forebody warping increased the range of stable trim, though restricting the center of gravity limits of stability; it improved landing stability and bow-spray characteristics. The high-speed water resistance, however, was increased slightly, and there was a slight decrease of takeoff performance in smooth water, though not in waves, all compared with test results from the basic model presented in previous technical Notes. J. R. Weske, USA

1176. Stanley H. Scher and Lawrence J. Gale, "Wind-tunnel investigation of the opening characteristics, drag, and stability of several hemispherical parachutes," *Nat. adv. Comm. Aero. tech. Note*, no. 1869, Apr. 1949, 27 pp.

The results of tests made to determine the opening characteristics, drag and stability of several hemispherical parachutes are given. The tests were made in the Langley 300-mph 7-by-10-ft wind tunnel at airspeeds up to 200 mph and in the Langley 20-ft free-spinning tunnel. Effects of shroud-line length, hem-line tacking, crown vent, fabric porosity and weight are discussed. Film strips, made at camera speed of 64 frames per sec, showing the opening of two different parachutes are presented.

E. Muhlemann, Switzerland

1177. Alun R. Jones, "An investigation of a thermal ice-prevention system for a twin-engine transport airplane," *Nat. adv. Comm. Aero. Rep.*, no. 862, 1946 (issued in 1948), 37 pp.

The report contains numerous data on temperatures of air and structure for a Curtis C-46 type airplane equipped with a heated-

wing thermal ice-prevention system. Stresses induced in the wing structure by the heated-wing system were measured. It was concluded that for some installations a means of regulating the heating to guard against loss of strength in the structure might be desirable. A detailed study of corrosion effects in the structure revealed that negligible corrosion was engendered by the heated-wing system. This report is significant because it represents a most thorough account of the effect of a typical heated-wing system on the structural and aerodynamic properties of an airplane.
Myron Tribus, USA

Aeroelasticity (Flutter, Divergence, etc.)

(See Rev. 1160)

Propellers, Fans, Turbines, Pumps, etc.

(See also Rev. 1151)

1178. **W. A. Loeb, "A study of the supersonic axial-flow compressor,"** *J. appl. Mech.*, Mar. 1949, vol. 16, pp. 19–26.

This paper presents an analytical study of two general types of supersonic compressors, namely those having: (1) a normal shock in the entrance to the stator; (2) a normal shock in the entrance to the rotor. Idealized flow conditions are assumed, and only blade elements are considered. Pressure ratios are calculated on the basis of perfect-gas considerations and the velocity diagrams. Radial effects and friction effects are not considered for this study. Curves are drawn showing pressure ratio and efficiency as a function of dimensionless wheel speed for the two cases considered. The author concludes that the compressor having a normal shock in the stator is superior to that having a normal shock in the rotor; and that the strongest restriction on this normal-shock-in-stator compressor is the Mach-number limitation in the rotor. The influence of the limitation of blade entrance angles is also discussed. Frank L. Wattendorf, USA

1179. **F. Ginzel, "Calculation of counterrotating propellers,"** *Nat. adv. Comm. Aero. tech. Memo.*, no. 1208, Mar. 1949, pp. 1–61 (transl. from *Zent. wiss. Berichtswesen Berlin Forschungsber.*, no. 1752, Jan. 1943).

This paper presents a method for the calculation of the aerodynamic characteristics of arrangements in which both propellers are placed close together on the same axis, have the same number and shape of blades, have the same diameters and equal but opposite angular speeds, but have different distributions of blade angle over the radius. The method is based on an extension of Walchner's method for single propellers which is essentially a modified blade-element theory. Following Walchner's lead, the present theory is simplified by the use of mean values of the induced velocities, instead of their actual periodically varying values.

The investigations are performed principally at the blade elements so that no presumption is made concerning the distribution of the circulation over the radius. After developing the theoretical characteristics for the blade elements, applications are made to calculate the properties of complete counterrotating propeller assemblies by both multisection polar methods. Comparisons are made with experimental results obtained by Lesley.

Several properties of counterrotating propellers important to a designer are discussed. These topics include the division of thrust and torque between the component propellers, the relative efficiency of different configurations, and the selection of blade-angle distribution for optimum performance.

The paper concludes with an analysis of counterrotating propellers having an infinite number of blades. Operating conditions ranging from the braking domain to heavy loads are considered. Several charts and tables are presented to facilitate application of the theory. John R. Spreiter, USA

1180. **F. B. Gustafson, "The application of airfoil studies to helicopter rotor design,"** *Nat. adv. Comm. Aero. tech. Note*, no. 1812, Feb. 1949, pp. 1–12.

The note presents a brief systematic discussion of the airfoil problems encountered in helicopter design. The collection of references is particularly valuable, and there is a brief discussion for each group of references.

References 1 to 9 provide the basic characteristics of all airfoils likely to be of interest in helicopter design, and cover the following: (1) NACA 4-digit and 5-digit airfoils; (2) NACA low-drag airfoils (other than special helicopter sections); (3) special helicopter sections; (4) section characteristics at angles of attack beyond the stall. References 10 to 38 are classified as giving information on the effects of various parameters such as: (*a*) Reynolds number; (*b*) Mach number; (*c*) surface condition; (*d*) effect of trailing-edge modifications on moment-coefficient values; (*e*) effect of trailing-edge modifications on aerodynamic-center values; (*f*) effect of trailing-edge modifications on drag; (*g*) effect of trailing-edge modifications on lift. References 39 to 48 are classified as discussing the application of airfoil section data to prediction of rotor characteristics, in theoretical treatment and practical verification.

The note should be of considerable help to helicopter designers.
Alexander Klemin, USA

1181. **Maurice Roy and Georges Gorge, "Universal diagrams for the study of the over-all efficiency of turbojets"** (in French), *Off. nat. Étud. Rech. aéro. Rep.*, no. 15, 1948, 53 pp.

The subject of this detailed study is the effect of the characteristic thermodynamic parameters of jet engines upon their efficiency and weight. Tables and curves are presented showing the influence of pressure ratio and maximum cycle temperature for sea level and 36,000-ft altitude, covering airplane speeds up to 1150 ft per sec.

Calculations of the changes in thermal, propulsive and over-all efficiency comprise part I of the paper; part II deals with variations of the ratios of thrust to engine weight and of thrust to frontal area for a family of dynamically similar engines. A separate study dealing with the effect of combustion-chamber pressure drop, variations in efficiencies of the inlet duct and the tail pipe, and of frictional losses is included in an appendix.

The analysis shows that an engine of highest thrust-weight ratio must be designed for a smaller pressure ratio than is required for best efficiency. A strong increase in thrust-weight ratio with cycle temperature is also apparent.
Andrew A. Fejer, USA

Flow and Flight Test Techniques

(See also Revs. 1152, 1197, 1218)

1182. **A. Bevert and A. de Sievers, "The Girerd and Seince balance of the Cannes wind tunnel"** (in French), *Rech. aéro. Paris*, Nov.-Dec. 1948, no. 6, pp. 35–41.

This article describes a wind-tunnel balance conceived by Girerd and Seince for use in the wind tunnel at Cannes, France. The construction of the balance, which is capable of measuring the six components of force and moment acting on a model, is de-

scribed in some detail. A special feature of the balance is the provision of a weather-vane arrangement whereby angles of trim can be determined simultaneously with the measurement of the components of the force system. This is an extension of a scheme developed at the Issy-les-Moulineaux laboratories in the late 1920's.

No indication is given as to the size or speed range of the wind tunnel for which the balance is designed, although a partial indication can be obtained from the fact that the lift capacity of the balance ranges from −60 kg to +210 kg. A considerable part of the discussion deals with problems of fidelity, sensitivity and accuracy of force measurements, with efforts to reduce the interaction between components, and considerations leading to a minimization of the tare drag of the balance and model supports. In the latter connection, the authors make use of the term, "drag . . . . of two types of karmans," and again "drag of the assembly airplane plus karman . . . ."; this terminology is not clear to this reviewer and his colleagues. M. J. Thompson, USA

In French terminology a "karman" is the fillet surface between the wing and the fuselage. Ed.

1183. "Aerodynamical balance for high-speed wind tunnel," *Engineering*, 1949, vol. 167: Feb. 25, pp. 175–177; Mar. 11, pp. 223–225; Mar. 25, pp. 272–274.

A rather detailed description of the six-component balance for the high-speed wind tunnel at the Royal Aircraft Establishment at Farnborough is presented. There is also included a short description of the tunnel. No information is given of the operational experience with this balance.

In general, the balance is a mechanical system which, by means of a rather complicated system of levers and bell cranks, separates the forces and moments, which are then measured by automatic weigh beams. The balance can also be arranged to read only three components. It is evident that a considerable effort was made to provide easy methods of making adjustments to the model supporting struts, balance linkage system and to the balancing units.

Helical springs are used for the initial balancing adjustment needed for balancing the weight of the model and linkage system, rather than the usual counterweights. The rider on the weigh beam is driven by a motor which, in turn, is controlled by a deflection-sensitive induction-coil unit on the beam. The output of this position-sensing device is amplified before it goes to the motor driving the beam rider. Since this response is proportional to the deflection of the beam, a modification is needed to prevent hunting of the rider. This is done by automatically reducing the gain of the amplifier as the motor speed increases. This arrangement reduces overtravel of the rider and at the same time retains the required sensitivity to small beam deflections. Beam damping is supplied by a dashpot, the damping value of which can be adjusted in the control room during operation.

Henry H. Hoadley, USA

1184. James C. Sivells and Owen J. Deters, "Jet-boundary and plan-form corrections for partial-span models with reflection plane, end plate, or no end plate in a closed circular wind tunnel," *Nat. adv. Comm. Aero. Rep.*, no. 843, 1946 (issued in 1949), 30 pp.

This report presents a method of determining the jet-boundary and plan-form corrections that must be applied to test data obtained in a closed circular wind tunnel on partial-span models with either a reflection plane or an end plate or no end plate at all. Examples are worked out for a partial-span model with each of the three end conditions in the Langley 19-ft pressure tunnel. The corrections are applied to measured values of lift, drag, pitching moment, rolling moment and yawing moment coefficients. For all corrections depending upon the wing lift distribution the plan-form corrections were small for the model with a reflection plane. The jet-boundary corrections were also small for the model using a reflection plane except for the rolling-moment coefficient. It is stated that the use of a reflection plane will give the best results for tests of a partial-span model. H. P. Liepman, USA

1185. R. Betchov, "Nonlinear theory of the hot-wire anemometer" (in French), *Proc. kon. Ned. Akad. Wet.*, Mar. 1949, vol. 52, pp. 195–207.

The author assumes the transfer of heat from the hot wire to the air to depend partly on the difference of temperature and partly on the square of that difference, expanding in this way the linear law of King. The differential equation, based upon this assumption and describing the change of the wire resistance with time and length of the wire, is solved exactly in an elegant way, for both the steady and unsteady state, the latter being created either by fluctuations of the current or of the flow. The total resistance of the wire is then obtained by integration.

Experience confirms the underlying hypothesis. The effect of the nonlinearity is greater than the effect of heat conduction in the wire. Wilhelm Spannhake, USA

Thermodynamics

(See also Revs. 1168, 1181)

1186. A. Tenot, "Applied mechanics of rigid and deformable systems, vol. 6, Reciprocating engines" (in French), Dunod, Paris, 1948. Paper, 8.5 × 5.2 in., 446 pp., 201 figs.

This volume deals with the mechanical and thermodynamical problems encountered in the design of reciprocating machinery.

In the introduction a general summary of the differences between turbomachinery and reciprocating machinery is given. The general principles which are important for all reciprocating machines are illustrated in the first chapter. The second chapter treats of the general thermodynamic laws which are of importance to the designer of reciprocating machinery. In the third chapter some problems relating to the design of reciprocating steam engines are treated. The general dynamics of the reciprocating machine is covered in detail in the fourth chapter. The problems of unbalance and torsional vibration are explained by means of numerous examples. The last chapter contains a number of problems covering the whole field of reciprocating machinery.

The author emphasizes especially the practical application of the general principles of mechanics and thermodynamics, and omits the principles which are only of theoretical interest. The theory is always illustrated by means of practical examples, which makes the book valuable not only to the student but also to the design engineer who is interested in applications.

E. Haenni, USA

1187. Antonio Capetti, "On the selection of the most economical compression ratio in gas turbines with partial regeneration" (in Italian), *Termotecnica*, June 1948, vol. 11, pp. 187–190.

The author establishes a relation between the effective area of the regeneration plant of a gas turbine, the fuel costs, the amortization rate, and annual time of use and power. From this relation the most economical area is determined analytically, when all other variables are held constant. The power and the specific fuel consumption however depend among other things on the compression ratio. Using a graphical method, the author determines the most economical compression ratio, when the regenerator area is also an optimum. Walter Wuest, Germany

1188. **Andrew Kalitinsky, "Atomic power and aircraft propulsion,"** *Soc. auto. Engrs. quart. Trans.*, Jan. 1949, vol. 3, pp. 1–17.

The paper gives an elementary outline of the fundamental physical background of atomic energy and stresses the fact that the development of atomic power is predominantly an engineering problem, and not one involving some new scientific discovery. After describing the elementary principles of atomic physics with the aid of good schematic diagrams, the author passes on to the atomic reactions in the sun, radioactivity, uranium fission, and chain reactions. The broad principles of nuclear reactors are enumerated together with a digression on the methods of shielding from the radiations originating within the reactor, and prevention of the escape of the violently radioactive fission fragments. In dealing with atomic power for aircraft the author maintains that the attractiveness of this proposal lies only in the use of planes which combine high performance with large pay load and long range. The high concentration of energy and the high cost and relative scarcity of atomic fuels thus mark them for use only where there is high premium on performance, and not on direct cost per unit of power. The chief obstacles in the design of atomic-powered aircraft are also described. The paper forms a preliminary springboard for future research and development in aircraft propulsion. S. K. Ghaswala, India

1189. **L. D. Armstrong and H. Grayson-Smith, "Specific heats of manganese and bismuth at liquid hydrogen temperatures,"** *Canad. J. Res. Sec. A*, Mar. 1949, vol. 27, pp. 9–16.

New measurements are reported for the specific heats of manganese and bismuth in the temperature range of 14 to 22 K. For both metals, in this temperature range, the specific heats are accurately represented by the approximate theoretical formula $C_v = C_D(T/\theta) + AT$ where $C_D(T/\theta)$ is the Debye function, θ is the characteristic temperature and A is the electronic specific heat coefficient. Comparison with measurements by other investigators at widely different (higher and lower) temperatures, however, indicate sharp changes in θ and A.

For manganese, it is estimated that θ varies from 365 to 390 deg with temperature, and $0.0035 < A < 0.0040$. For bismuth, A is negligible permitting accurate determination of θ, whence the variation of θ with temperature is found to be remarkably similar to the relation calculated by Blackman for a simple cubic lattice. K. W. Miller, USA

Heat Transfer; Diffusion

(See also Revs. 1154, 1157, 1177, 1189, 1208)

1190. **M. Vasseru, "Forced convection of heat in the laminar boundary layer at the surface of a body of revolution"** (in French), *Rech. aéro. Paris*, Sept.-Oct. 1948, no. 5, pp. 65–69.

The local coefficient of heat transfer at the surface of figure of revolution is calculated from the theory of the laminar boundary layer. The main flow is directed parallel to the axis of revolution.

It is shown that the problem may be reduced to the solution of a similar problem for a cylinder whose generatrices are perpendicular to the direction of flow. The shape of the cylinder is found from a transformation of variables which makes the system of partial differential equations for the body of revolution identical in form with the equations for a cylinder. After the boundary-layer equations for the velocity and temperature distributions have been solved for the equivalent cylinder by a numerical method, the velocity and temperature distributions and the heat transfer coefficients for the body of revolution follow directly from the transformation of variables. Calculations for the boundary layer around a sphere are given. R. L. Pigford, USA

1191. **Haruumi Asao, "A numerical determination of temperature and velocity of viscous fluid in cooling or heating pipes (1st report)"** (in Japanese), *Trans. Soc. mech. Engrs. Japan*, 1947, vol. 13, no. 44, pp. 148–154.

The author develops a numerical method for solving the problem of laminar heat transfer in a circular pipe. In this first report the change of viscosity with temperature is neglected, and the temperature distribution in the pipe is obtained for a flow with parabolic distribution of velocity (Poiseuille flow). The author calculates the mean temperature (mixing-cup temperature) at various sections, and compares his values with those obtained from the analytical solution. Except in the neighborhood of the initial section, the agreement is satisfactory, the error being within 0.6 per cent, on the average. Humio Tamaki, Japan

1192. **Haruumi Asao, "A numerical solution of temperature, velocity and pressure distribution of oil in cooling pipe"** (in Japanese), *Trans. Soc. mech. Engrs. Japan*, 1948, vol. 14, no. 48, part 2, pp. 18–25.

This paper is the second report of the author's work on the heat transfer in a circular pipe. His numerical method is generalized for solving the equations of motion and heat transfer simultaneously. For castor oil flowing through the cooling pipe, the distributions of temperature and velocity and the pressure drop are calculated, assuming parabolic distribution of velocity at the initial section. The velocity becomes smaller in the neighborhood of the wall, and larger in the center. It is also shown that the pressure drop is not constant, but becomes larger as the distance from the initial section increases, owing to the increase of viscosity. The author points out that the efficiency of cooling is lowered because the cold oil adheres to the wall, while the warmer oil passes through the central part and is not cooled sufficiently. Humio Tamaki, Japan

1193. **H. Kühne, "The calculation of heat exchangers"** (in German), *Z. Ver. dtsch. Ing.*, Mar. 1948, vol. 90, pp. 92–94.

This article is a brief extract from a book [*Die Grundlagen der Berechnung von Oberflächenwärmeaustauschern*, by H. Kühne, Verlag Vandenhoeck Ruprecht, Göttingen]. It presents a method intended to eliminate the need for successive approximations in calculations of heat-exchanger size needed for a given application. Equations of conventional form are combined to yield relations for over-all thermal resistance in terms of the exponents and numerical coefficients associated with the effects of Reynolds and Prandtl numbers on heat transfer and friction. An arrangement for plotting, from these relations, a family of curves of surface area versus over-all thermal resistance is then explained. These curves represent various values of a parameter which is a product of several factors, including pressure drop, volume flow rate and a function φ (not clearly defined). R. Hosmer Norris, USA

1194. **J. G. Aston and G. J. Szasz, "On a method of correcting for incomplete thermal isolation in measurements of small heat capacities,"** *J. chem. Phys.*, Aug. 1947, vol. 15, pp. 560–561.

The usual method of correcting for incomplete thermal isolation is not generally applicable at temperatures below 20 K where the heat capacity of the shield and calorimeter with contents drop to a very small value. Keesom and Kok [*Proc. kon. Ned. Akad. Wet.*,

1932, vol. 35, p. 294] derived expressions for the corrected mid-time t^* of the heat capacity, i.e., the time to which the fore and after drifts of temperature should be extrapolated.

The authors simplified this treatment in such a manner as to make it applicable to heat-capacity measurements in which the temperature of the system is known only before and after heating, and deduced the following approximate formula:

$$t^* = (t_1/2) - (k/c)(t_1^2/12)$$

where t_1 is the actual time of heating, k the heat exchange between calorimeter and shield in cal per deg temperature difference per sec, and c the true heat capacity of the system studied.

Z. Horák, Czechoslovakia

Acoustics

1195. Piero Giorgio Bordoni and Wolf Gross, "Sound radiation from a finite cylinder," *J. Math. Phys.*, Jan. 1949, vol. 27, pp. 241–252.

The authors have calculated the acoustic field characteristics generated by a finite rigid cylinder with one base vibrating uniformly and the other surfaces at rest. The problem leads to the Neumann problem for wave fields, as distinct from that of potential theory. The procedure is to develop the solution in terms of Legendre and Stokes functions [Rayleigh, *Theory of sound*, II, pp. 237–238, sec. ed. revised] and then to satisfy the assigned boundary values in the mean, instead of satisfying them at every point on the surface of the cylinder.

By taking the difference of the calculated and the preassigned values of the normal velocity at the surface, squaring and integrating over the surface of the cylinder, and afterwards minimizing these integrals with respect to the complex coefficients, the authors have obtained a set of linear equations in the coefficients of the development of the velocity potential. This procedure gives not only the exact solution (velocity potential) as the number of terms approach infinity, but also all its derivatives.

By retaining a finite number of terms of the development, one can determine the coefficients of the expansion by solving the linear equations which result from the minimizing process. These coefficients are expressed as functions of kr, Ci (kr) and Si (kr), $k = 2\pi/\lambda$, r is radial distance. The authors have tabulated values of the first five pairs of coefficients for values of $kr = 0.5$, 1, 2.5, 5, and the directional characteristics of the cylinder have been plotted. A comparison is made with the characteristics of the equivalent spherical (sectorial) cup (angular opening 60 deg 52 min). It is found that for small values of kr (low frequency), the characteristics of the cylinder differ little from those of the rigid sphere, but for higher frequencies the cylinder shows more selectivity than the sphere. The power radiated falls down rapidly with kr. It is somewhat lower than the power radiated by the equivalent spherical cup, although the shapes are very similar for both.

N. Chako, USA

Ballistics, Detonics (Explosions)

1196. J. L. Copp, S. E. Napier, T. Nash, W. J. Powell, H. Skelly, A. R. Ubbelohde and P. Woodward, "The sensitiveness of explosives," *Phil. Trans. roy. Soc. Lond. Ser. A*, no. 831, Aug. 10, 1948, 106 pp.

This paper is a compilation of the results of the research of the authors during the war years on the sensitiveness of explosives. The chief purpose of this research was to determine manufacturing precautions and methods of safe handling of explosives and to determine what initiators can be used. In pursuit of the main purpose a number of notable contributions were made to the understanding of the fundamental physicochemical properties of explosives. The paper emphasizes the fact that the process of detonation is very complex and probably not the same in all explosives. The authors give their own carefully considered analyses of their experiments but at the same time provide the reader with enough data and information on the conditions of the experiments for him to draw his own conclusions.

Because of the high speed with which a detonation wave travels across successive layers of molecules, it is concluded that the most plausible mechanism for this propagation of detonation is that collisions of fast moving molecules from behind the detonation front must activate those in the quiescent layer ahead. Practically every such collision must lead to activation. This high activation efficiency is ascribed to two things: (*a*) The high temperature of the molecules behind the detonation front gives them high random velocities. (*b*) The hydrodynamical conditions of shock propagation gives the molecules behind the detonation front a high directed velocity toward the unreacted layer. In some initiations (*a*) may be more important, whereas in other cases (*b*) may be more important. This may account for some of the lack of correlation between the different standard tests for sensitivity. Attempts are made to devise tests in which these two factors are separated.

The paper is so packed with important ideas, facts and conclusions that it is impossible to review them in a few words. Only a few high lights can be given. The determination of the activation energies for various initiators and explosives is very adequately covered. Routine tests for sensitiveness to heat, percussion and friction are examined and these tests are redesigned to give more physicochemical information. Important conclusions are reached concerning the sensitizing effect of grit included in the explosives and also concerning the desensitizing action of liquids of various boiling points. The effect of compression on initiators and explosives is to render some less sensitive while others are made more sensitive.

Emerson M. Pugh, USA

1197. Freeman K. Hill and Ralph A. Alpher, "Base pressures at supersonic velocities," *J. aero. Sci.*, Mar. 1949, vol. 16, pp. 153–160.

This paper describes an experimental study of base pressures of slender, fin-stabilized missiles in free flight over a range of Mach numbers from 2.5 to 0.7, a study carried out by the Applied Physics Laboratory, Johns Hopkins University. All missiles had the same basic shape, an ogival head with a square-ended body (4 in. diam), but their fineness ratios ranged from 6 to 30. Each was rocket-boosted to full velocity, the booster jettisoned, and the flight record made during the free run as the missile decelerated from peak (Mach nos. 1.9 to 2.5) to terminal velocity (Mach no. 0.7). Pressures were telemetered from gages in the missile; the complete instrumentation provided a record of base pressure, Mach number, and other pertinent data throughout the flight. Furthermore, the flight tests on the shortest missile were supplemented by wind-tunnel measurements in the Daingerfield tunnel (Mach no. 1.73).

The principal result is contained in a graph of the base-pressure coefficient, p_B/q, against Mach number. Tests on various configurations indicate that the pressure is uniform across the base, and does not change significantly with either angle of attack or length of the missile. The results are compared with measurements in other wind tunnels (Koechel, Guidonia) and in the Aerodynamics Range (Aberdeen Proving Ground), but the agreement is not too satisfactory, the APL flight data being consistently low.

The author also concludes that the fins have little or no effect

on the base pressure. On the other hand, the reviewer has had access to limited tests in the Aberdeen supersonic wind tunnel, and these tests indicate that the fins may affect the base pressure and, in fact, in the right direction to account at least partially for the disagreement. A. C. Charters, USA

Soil Mechanics, Seepage

(See also Rev. 1207)

1198. **G. Wilson and J. L. E. Sutton, "A contribution to the study of the elastic properties of sand"** (in English), *Proc. Sec. int. Conf. Soil Mech. Found. Engng.*, 1948, vol. 1, pp. 197–202.

In a historical introduction the authors state their disagreement with the Boussinesq stress distribution in an elastically isotropic homogeneous semi-infinite mass, under the action of a vertical load if that stress distribution is applied to actual sand masses. In the latter case the stresses are concentrated more closely around the vertical axis through the loaded area, and are consequently greater in the neighborhood of that axis. To explain this well-known fact, the authors have investigated the values assumed by the tangent Young modulus in the course of triaxial compression tests on two different sands, a coarser studied by the authors, and a finer studied by Messrs. Casagrande and Watson at Harvard University. The tangent Young modulus E is the derivative $d\sigma/d\epsilon$, the symbol σ standing for the average normal stress and ϵ for the linear strain. The values of the tangent modulus E are functions of the two variables: the sum of principal stresses H and the maximum shear τ, and not only of the variable H.

The surfaces representing this relationship are shown axonometrically in several drawings; using E, H, and τ axes. The trace of each of such surfaces on the E-H plane is a curve that according to the author's computations should be a cubic parabola; and sections of a surface by a plane H-τ or some other plane parallel to it are practically straight lines.

Families of such straight lines drawn on the plane H-τ are given for various degrees of compaction of the tested samples and for various values of applied stresses. The authors' conclusion is that the results presented show the overwhelming importance of the maximum shear stress (or in other words, the principal stress differences) in the stress distribution which was not taken into account by Boussinesq. D. P. Krynine, USA

1199. **E. E. De Beer, "The calculation of girders resting on soil—the modulus of soil reaction, *K*"** (in French), *Ann. Trav. publics Belg.*, 1948, vol. 101: June, pp. 393–413; Aug., pp. 525–552; Oct., pp. 653–691; Dec., pp. 721–749.

The classical method for solving reaction patterns under a footing is to assume that the footing rests on an infinite number of columns, the deformation of which is in direct ratio to the reaction according to the law $p = Ks$, where p is the reaction and s the settlement. The author shows that this method, neglecting the vertical shear in the soil, is analogous to considering the soil a heavy liquid. The Schiel-Wieghardt modification is shown to be similar to the classical method with superficial tensions added.

The author proves that both methods are erroneous and proposes instead to solve the problem by successive approximations of the deformation of the footing and of the soil. The soil is considered both heterogeneous and anisotropic but in such a way that its modulus of elasticity varies according to depth; thus the stress at any point and in any direction due to a concentrated load may be found by using Fröhlich's and Buisman's formulas, and may be found by combining them with Newmark's diagram for a distributed load. The settlement at the surface of the soil is then considered as the sum of the elementary settlements under the point considered and may thus be linked to the stresses.

In some cases it may be possible, by integration, to find an equation for the reactions which will apply both to the elastic curve of the footing and to the soil surface, but in most cases it is necessary to start with a given reaction pattern and proceed by successive approximations until a fair agreement is reached. Numerous problems are treated as examples, and a series of tests performed to estimate the precision of the method, are described in detail. It is shown that for long beams a fourth-degree parabola coupled with a logarithmic function will give a very accurate reaction diagram if the soil corresponds to the Rhine sand used in the tests, while a second-degree parabola will usually give results more accurate than those from either the classical or the Schiel-Wieghardt theory.

In dealing with soils for which one of the basic assumptions does not hold, for instance those which have a Poisson's ratio not equal to 0.5 or a modulus of elasticity not proportional to the stress, the final simplifications do not apply, but the method is still valid and could be used in a number of practical problems.

Robert Quintal, Canada

1200. **M. Lacroix, "Electric soil consolidation"** (in French), *Ann. Ponts Chauss.*, Sept.-Oct. 1948, vol. 118, pp. 621–643.

This paper is a résumé of the work done to date on soil consolidation using electrochemical methods. Reference is made to recent Russian experiments on soil solidification by electrical means and a more detailed account is given of L. Casagrande's work in soil consolidation by electro-osmosis [*Build. Res. tech. Pap.*, no. 30]. A brief account of similar investigations being carried on by Beskow in Sweden is also included.

Eben Vey, USA

Geophysics, Meteorology, Oceanography

(See also Rev. 1158)

1201. **Robert O. Reid, "A model of the vertical structure of mass in equatorial wind-driven currents of a baroclinic ocean,"** *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 304–312.

This is an extension of an earlier paper by H. U. Sverdrup [*Proc. nat. Acad. Sci. Wash.*, 1947, vol. 33, pp. 318–326] in which the horizontal distribution of mass in the central equatorial Pacific is derived from the surface-wind stress. An idealized form of the vertical density distribution is assumed, and lateral stresses, local heating and cooling, and the nonlinear inertia terms are neglected. Comparison of the theoretical results with a section observed by the Carnegie Institution shows good agreement.

Henry Stommel, USA

1202. **Walter H. Munk and Ernest R. Anderson, "Notes on a theory of the thermocline,"** *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 276–295.

This very important paper presents the results of some computations made on the differential analyzer of the University of California from the equations of downward turbulent flux of heat, salt, and momentum simultaneously. The aim of the work was to explain the origin of the thermocline (which begins at a point of sharp discontinuity in the vertical temperature gradient occurring at depths of from 10 to 100 meters in the ocean). The very radical departure of this paper from all preceding ones consists in taking the eddy coefficients of conductivity, diffusivity, and viscosity as prescribed functions of depth; they are assumed to de-

pend explicitly upon stability, shear, and gravity in an empirical manner. The results therefore have a degree of generality seldom attained in fluid mechanics. The most restrictive assumption is that the net heat flux be directed downward and that there be no convective stirring such as might occur due to surface cooling by evaporation.

Because of the numerical nature of the method of solution, particular cases were chosen where observational checks were available: (*a*) a situation observed from a weather ship; (*b*) a broad mid-Pacific strip where the effect of latitude could be checked; (*c*) a lake where seasonal changes had been observed. In the first two cases the computed thermocline turned out to be rather too shallow; for the lake, however, observation and computation were in good agreement. In all, 21 runs of the analyzer were successfully completed. Henry Stommel, USA

1203. W. H. Munk, G. C. Ewing, and R. R. Revelle, "Diffusion in Bikini Lagoon," *Trans. Amer. geophys. Un.*, Feb. 1949, vol. 30, pp. 59–66.

The vertical diffusion and the horizontal diffusion of radioactive material in the lagoon at Bikini after the Baker-day tests were of enough importance to warrant preliminary measurements and calculations. Tests of actual diffusion after the atom-bomb explosion showed that the horizontal diffusion had been predicted with excellent accuracy, but not the vertical diffusion. Patchiness in deposition of material and upward currents near the reef were causes of this inaccuracy. A quantitative discussion of these diffusion coefficients is given. W. C. Johnson, Jr., USA

1204. A. Nizery, "Study of deformations of the swell in the vicinity of a pier" (in French), *Houille blanche*, 1948, spec. no. A, pp. 628–633.

The author discusses the wave pattern on the lee side of the end of a pier by using the results of classical optical-diffraction theory. The analogy is valid if the wave length is much larger than the depth of the sea (which must be constant). Since these conditions do not normally exist, the analogy is qualitative, not quantitative. H. J. Stewart, USA

1205. J. W. Johnson, "The characteristics of wind waves on lakes and protected bays," *Trans. Amer. geophys. Un.*, Oct. 1948, vol. 29, pp. 671–681.

In order to determine the characteristics of waves generated by wind blowing over lakes or bays protected from ocean swell, observations were made at Clear Lake, California. Aerial photographs were analyzed for wave length and for length along the crest, and a statistical analysis was made of the two series. Later on, two observation stations were established at Clear Lake, and investigations made of wave height and period both visually (using a graduated pole) and by a pressure recorder located below the still water surface.

The various data on wind and wave characteristics were critically examined and compared with a diagram of the Hydrographic Office obtained from observations in the ocean, and also with wind-tunnel measurements of the late Lord Stanton (1932) and Flinsch (1945 unpublished). The Clear Lake data fall above the Hydrographic Office curves for wave period and below for wave height. The latter fact might be expected if the wind duration was below the minimum required by a wind of a given velocity to raise the highest possible waves at the end of a given fetch. Recommendations are made for further field investigations and flume experiments. Some of these recommendations have already been verified in a new German investigation by H. U. Roll. Walter Wuest, Germany

1206. Alfred C. Redfield, "The exchange of oxygen across the sea surface," *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 347–361.

In temperate latitudes the oxygen content of sea water near the surface varies with the season, because the solubility of oxygen in water changes with temperature and because the production and utilization of oxygen by organisms is unequal at different seasons. In this paper the magnitude of the change in oxygen content in the Gulf of Maine and the factors responsible for it are discussed.

From data collected in the course of a survey of the Gulf of Maine made by the *Atlantis* in 1933–1934, the following conclusions were drawn: (1) About 30×10^4 cc of oxygen per sq m leaves the surface between the end of October and the latter part of March, and a like amount reenters from the atmosphere during the alternating periods. (2) The net production and consumption of oxygen by organisms accounts for 2/5 of this exchange. (3) The pressure head of oxygen across the sea surface agrees in direction with the estimated movement of oxygen. (4) The exchange coefficient of oxygen is about 13×10^6 cc per sq m per atmosphere per month in winter and about 2.8×10^6 in summer. This seasonal difference is attributable to the conditions at the sea surface such as waves and turbulence which cause errors in the measurements. Karl E. Schoenherr, USA

1207. K. O. Emery and J. F. Foster, "Water tables in marine beaches," *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 644–654.

Measurements of the profiles of the water tables on several beaches show that during ebb tide the seaward edge of the water table generally slopes seaward, while during flood tide it slopes landward. Inflow of water from large waves washed high on the beach is responsible for the fact that the average seaward slope of the outer part of the profiles taken during ebbing tides is less steep than the average landward slope at flooding tides. Water escapes from the beach during ebb tide with a velocity sufficient to elutriate silt grains, and it may collect into rivulets which erode small rill channels across the beach. The evaporation of some salt water drawn by capillarity to the sand surface explains the rigid crust cementing the sand. L. J. Tison, Belgium

1208. Gunnar Beskow, "Scandinavian soil frost research of the past decade," *Proc. Highw. Res. Bd.*, 27 Ann. Meet., 1948, pp. 372–383.

This paper contains a summary of results on the subject of frost action in soils obtained by investigators in Norway and Sweden since 1937. Formulas are presented by means of which the depth of frost penetration can be estimated under various soil and climatological conditions. The importance of the influence of heat conducted from the zone below the depth of frost penetration, and the effect of a snow cover on the depth to which frost will penetrate are demonstrated. It is reported that the heat conductivity of snow is 10 to 15 per cent of that of common soils, and the insulating value of a snow cover is thus equivalent to that of a layer of soil seven to ten times its thickness.

The paper includes empirical data concerning the thermal properties of soils. The practical use of frost penetration calculations is demonstrated by several examples, and measures that can be taken to obtain maximum frost penetration resistance are discussed. Experience with the use of some soil stabilizing agents as they affect frost action is also reported.

A discussion of this paper by W. L. Shannon stresses the limitations of theoretical methods in determining the actual depth of frost penetration in a given instance. It is his opinion that such methods contribute substantially to a proper understanding of the effects of the many variables that influence the depth of frost penetration. Ralph E. Fadum, USA

1209. **Jacob Bjerknes, "Atmospheric tides,"** *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 154–162.

The resonance theory of atmospheric oscillations requires that the atmosphere have a natural period, always within a few minutes of 12 solar hr, in spite of seasonal and geographical variations in the temperature of the atmosphere. The author considers that if the variation in phase with height of the 12-hr oscillation (deduced by Wagner from Alpine data) were taken into account in the mathematical theory, it would be found that the same sharpness of tuning would no longer be required. He gives some qualitative arguments in support of this contention.

M. V. Wilkes, England

1210. **Hans Ertel, "The thermic and potential energy of atmospheric actions centers"** (in German), *Z. Met.*, May-June 1947, vol. 1, pp. 225–229.

The author's objective is to prove that in certain circumstances the internal and potential energy of the atmosphere in a cyclonic or anticyclonic region may be determined from surface measurements alone. He assumes the atmosphere to be an inviscid perfect gas of constant specific heats, takes the earth's surface to be plane, supposes the vertical component of the dynamical equations to reduce to $dp = -g\rho dz$, and regards the Coriolis acceleration as constant and, on the boundary of the region, much larger than the convective acceleration. Writing the equations of motion in a rectangular Cartesian system, the author integrates the x and y components from $z = 0$ to $z = \infty$, and succeeds thus in deriving a single partial differential equation containing as dependent variables the internal energy of a cylindrical region and the integral of the pressure over the base of the cylinder, and as independent variables x, y, and t. This establishes the desired result, since the boundary conditions involve only surface quantities. The author carries out the calculations in detail, including the solution of the equation and the consideration of some numerical values.

The reviewer notes that an infinite amount of the volume of the cyclone or anticyclone is neglected by approximating the earth's surface as plane, for the integration from $z = 0$ to $z = \infty$ then sums over a cylinder rather than a cone. Perhaps under the present approximations, it would be possible to perform similar calculations in spherical coordinates and obtain a similar result.

C. A. Truesdell, USA

1211. **C. G. Rossby, "On displacements and intensity changes of atmospheric vortices,"** *J. Mar. Res.*, Nov. 1948, vol. 7, no. 3, pp. 175–187.

The author analyzes axially symmetric vortices imbedded in an atmospheric environment which is undisturbed or in geostrophic equilibrium. By integration over a horizontal slice of the vortex, it is shown that the effect of the Coriolis acceleration will be to introduce an unbalanced force which will cause anticyclonic eddies to move southward and cyclonic eddies to move northward. For a barotropic cyclonic vortex rotating as a solid, it is demonstrated that this movement is accompanied by a diminution of rotational energy and an increase in translational kinetic energy, and that the expressions for these changes yield results of the proper order of magnitude. Changes in kinetic energy of the environment are neglected.

Examination of a baroclinic anticyclonic vortex of zero absolute vorticity yields a similar result, except that in the southward movement of the vortex a loss of potential energy occurs. A more general application of these principles to vortices which rotate in the same sense at all levels is inferred. It is suggested, however, that in the case of baroclinic vortices which reverse in sense with height, the latitudinal motion of the complex eddy (moving so as to maintain its vertical axis of rotation) may cease at an equilibrium latitude at which the net force due to the Coriolis accelerations acting at all elevations vanishes. It is pointed out that cyclogenesis frequently is observed to occur above broad low-level anticyclones, and that tropical cyclones have been observed to form below anticyclonic eddies in the upper troposphere.

George S. Benton, USA

1212. **Heinz Lettau, "On the extremes of barometric pressure as function of the rotation of the earth"** (in German), *Met. Rdsch.*, Sept.-Oct. 1947, vol. 1, pp. 99–100.

The author desires to compute a maximum for the pressure difference between a high and a low. Following certain considerations of Kleinschmidt, Ertel, and others, under assumptions too numerous to list here, he derives $\Delta p < 8\rho L^2 \sin^2\phi/T^2$, where L is the period of the assumed harmonic variation of pressure normal to the isobars, ϕ is the latitude, and T is the period of the earth's rotation. This result is not contradicted by experience. By further approximations, the author obtains the sharper inequality, $\Delta p < 5\rho L^2 \sin^2\phi/T^2$. C. A. Truesdell, USA

1213. **N. P. Sellick, "Horizontal wind fields and pressure gradient,"** *Quart. J. roy. met. Soc.*, July-Oct. 1948, vol. 74, pp. 266–276.

An attempt is made to calculate pressure fields for given flow patterns in an isobaric surface. The calculation holds for thin layers of the atmosphere only, as friction and motion across the isobaric surface are neglected. Relatively simple expressions in Cartesian coordinates can be found to represent fields with deformation or divergence or even a simple cyclone model.

Horst Merbt, Germany

1214. **Günther Hollmann, "Air-pressure changes at high altitudes due to isobaric vertical movement at advective temperature changes"** (in German), *Z. Met.*, June 1948, vol. 2, pp. 161–168.

In this paper the author discusses in detail the "principle of compensation" which is of great importance in synoptic meteorology. This principle explains the observation that temperature fluctuations near the ground rarely are accompanied by corresponding pressure fluctuations.

The author proceeds on a mathematical basis and shows that the compensation discussed is a consequence of flow equilibrium which exists in the atmosphere to a high degree of approximation. The special case of constant atmospheric pressure near the ground while the temperature changes is a consequence of geostrophic flow equilibrium throughout the vertical extent of the atmosphere. The thermic part of ground-pressure variation is compensated by the pressure equivalent of a divergence of the geostrophic wind-velocity field arising from a horizontal temperature gradient. Pressure variation some distance above the ground is caused by vertical movements which can be derived from the divergence of the horizontal flow by the continuity principle. A formula for this vertical movement is derived which agrees with one found in an entirely different manner by G. Stuve. Other consequences of the theory are discussed more briefly. K. E. Schoenherr, USA

1215. **Heinz Lettau, "On the nongeostrophic wind component and its calculation from the pressure field"** (in German), *Met. Rdsch.*, Sept.-Oct. 1947, vol. 1, pp. 85–87.

The existence and importance of nongeostrophic wind com-

ponents is well known, but normally the weather service deals with the geostrophic or gradient wind only. An attempt is therefore made to give a simple expression for the nongeostrophic wind components. By successive approximations the author derives from the general Eulerian equation for horizontal motion expressions of first and second order for the nongeostrophic component. The result is especially simple in the case of stationary flow where $v_{stat} = v_{geostr}\,(1 - \Delta p/\rho l^2)$, $\Delta p = \partial^2 p/\partial x^2 + \partial^2 p/\partial y^2$ which can be easily computed from the weather map. The argument is illustrated by one example.

Horst Merbt, Germany

1216. Seymour L. Hess, "Some new mean meridional cross sections through the atmosphere," *J. Met.*, Dec. 1948, vol. 5, pp. 293–300.

In this paper, new meridional cross sections of virtual temperature, virtual potential temperature and geostrophic west wind along longitude 80 deg W are presented for summer and winter. The data were obtained from published and unpublished monthly summaries covering the years 1942–1945 inclusive.

The sections represent an improvement over previous efforts of this kind because they are based upon a longer period of observation, extend over a wider range of latitude and are more nearly along a meridian. Certain new features of these cross sections are pointed out.

Karl E. Schoenherr, USA

1217. Joanne Starr Malkus, "Effects of wind shear on some aspects of convection," *Trans. Amer. geophys. Un.*, Feb. 1949, vol. 30, pp. 19–25.

In convection processes the discussion concerning an ascending jet has, up to the present time, been centered on the conception of a steady environment. Actually, however, a variation of the horizontal wind with height is always observed. The magnitude of this difference is found by the author to be a function of the vertical shear and of the rate of entrainment of mass into the jet.

The effect of the relative horizontal velocity on the slopes of dry thermals and on cumulus-cloud processes is discussed by the author, and the observed horizontal asymmetries in the turbulence associated with trade cumulus are offered as an example.

S. K. Ghaswala, India

Lubrication; Bearings; Wear

(See also Rev. 1154)

1218. J. W. Wilson and Gerould H. Smith, "Calculating pressure-flow relations for lubricating greases," *Indust. Engng. Chem.*, Apr. 1949, vol. 41, pp. 770–776.

An empirical equation has been developed for the calculation of the pressure-flow relations for non-Newtonian systems. This equation takes into account the softening due to the thixotropic change in the flowing material. Results of numerous experiments with lubricating greases satisfy the equation within the limits of experimental error. The effect of pressure upon apparent viscosity of lubricating oil-grease up to about 1000 psi is indicated.

R. C. Binder, USA

1219. J. N. Good and Douglas Godfrey, "Changes found on reciprocated steel, chromium plate, and cast iron sliding surfaces," *Proc. Amer. Soc. Test. Mat.*, 1948, vol. 48, pp. 841–856.

This paper deals with chemical changes, changes in surface hardness and in crystallite sizes found on surfaces of metals when sliding on one another under load with boundary lubrication. The authors investigated specimens made of used and unused standard aircraft-engine cylinder barrel and piston-ring materials. The tests were carried out on a slider machine consisting of a reciprocating slider and a fixed rider loaded by gas pressure.

Investigations covered various conditions of running-in and load. Microchemical and metallographic methods were used to detect the chemical changes, while the changes in crystallite size were measured by X-ray diffraction. Microhardness testers determined surface hardness, while the depth of penetration of changes was determined microscopically on cross and tapered sections. Chemical changes consisted of oxidation and carburization.

Run-in steel surfaces resulted in Fe_3O_4 and high hardness on the surface, while at breakdown Fe_2O_3 and iron carbide were predominant. The sliding of cast-iron surfaces on one another resulted in graphite formation on the surface. The crystallite sizes were of the order of 10^{-7} cm, and growth of size only occurred with scuffing.

Nicholas Sag, Australia

Marine Engineering Problems

(See Rev. 1175)